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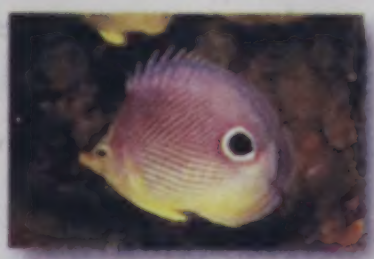
SCIENCE

9

Biology

Part 2



NINTH STANDARD

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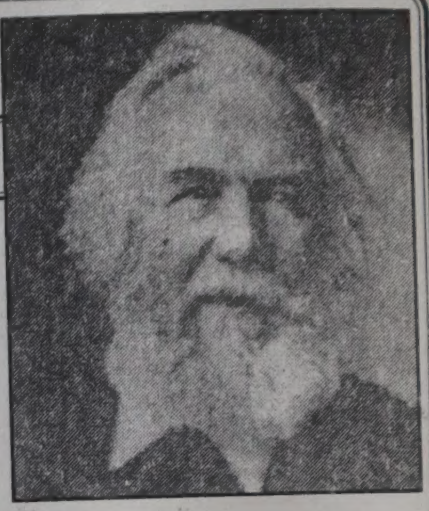
CHARLES DARWIN

FATHER OF "EVOLUTIONISM"

(1809-1882)



Darwin propounded the revolutionary "THEORY OF EVOLUTION" in which he explained that different living species attained their present forms after a long and gradual process of evolution. Darwin maintained that man descended from ape regarding the origin of human species.

Darwin reached these conclusions after years of hard and patient research. In December 1834, he got an opportunity to sail around the world abroad the ship "BEAGLE". Darwin returned from his long voyage in October 1836. During this period, Darwin studied different living species in different regions and put his observations in his diary. When he reached South America, he compared living species available there with that of Europe. He thus gathered a wealth of details about flowers and animals, rocks and fossils. Darwin, in fact, tried to connect the loose ends in the theory of the evolution of man. In 1859, Darwin published his most famous

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FOREWORD

This text book is prepared as per the syllabus framed based on National policy on Education 1986. The Core Elements and Human values that are stressed in the National policy on education are addressed at length in developing lessons.

The Directorate is greatful to all those who have participated in the production of this book.

The Text Books are reprinted after editing and making necessary corrections. The Directorate welcomes suggestions for further improvement of the book.

(M. Jalaja Bai)

Director
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Unit 1 : Ways of Living

CHAPTER I

STRUCTURE AND FUNCTION OF CELLS

1.1 Introduction

All living organisms, from bacteria to giant trees, from Amoeba to man, have a common unit of structure – the cell. While a bacterium or an Amoeba has a single cell, a tree or a man is composed of billions of cells. All these cells share a number of common characteristics. The cells are also units of function, each kind of cell performing a set of specific tasks. Nerve cells are specialized for carrying messages from one part of the body to another, muscle cells are specialized for contraction and expansion, and so on. In plants, there are cells meant for separate functions such as storage, protection, conduction of water, and so on. The cell is, therefore, defined as the **basic, structural and functional unit of an organism.** Hence, it is appropriate that we begin the study of biology with a detailed description of the cell structure and its processes.

1.2 Structure of a Typical Cell

When a cell is examined under a compound microscope one can make out three prominent structures, namely, the cell membrane, the cytoplasm and the nucleus.

Activity 1.1: Observation of animal and plant cells.

(a) Observe a typical animal cell under a compound microscope. Notice the parts such as cell membrane, Nucleus etc.

(b) With a mounted needle remove a tiny portion of the red, fleshy part of a tomato fruit. Mount in water on a slide and gently squash it with a coverslip. Examine under the microscope.

Cell Membrane

The cell membrane is a thin, delicate covering around the cytoplasm. It is also known as **plasma membrane**. Under an electron microscope it appears as a thin sheet similar to a waxed paper or a sandwich wrap. The cell membrane is an active, functional part of the cell. There are minute pores in the cell membrane that select and permit specific molecules to enter the cell or go out. Thus, it is described as a differentially permeable or selectively permeable membrane.

Activity 1.2 : To show the selectively permeable nature of the cell Membrane.

Cut the skin (peel) of a lemon into strips. Place one strip in a basin of water. Place another strip in another basin of water and boil it for about 5 minutes. Place a third strip in yet another basin of water to which a few drops of chloroform or ether have been added. Set aside the three basins for about half an hour. Later, examine the strips of the lemon peel. Only the strip in the first basin will have remained turgid. Why is it so?

The cell membrane acts as a barrier that separates the inside of a cell from its outside. Therefore, materials must cross this barrier if they are to enter or leave the cell. In other words, the plasma membrane has to regulate the movement of materials into and out of a cell. Let us look at the forces which operate in the cell membrane to bring about such a movement.

Diffusion is an important process where a random movement of molecules occurs from a region of higher concentration to a region of lower concentration. This difference in the concentration is known as concentration gradient.

Osmosis is a process in which a weak or dilute solution moves towards a strong solution when the two are separated by a semipermeable membrane. In a cell osmosis is a special type of diffusion which involves the net movement of water molecules across the cell membrane. Such a movement of water across a cell membrane goes on as long as there is a difference in the concentration of water on either side of the membrane.

Activity 1.3 : To Demonstrate Diffusion

Take a beaker containing water. Drop a fairly large crystal of potassium permanganate into it and observe. You will see that the purple colour of permanganate spreads in water gradually and ultimately the entire water becomes uniformly coloured. What causes potassium permanganate crystals to behave this way?

Activity 1.4 : To Demonstrate Osmosis

Peel the skin of a potato. Scoop a cup–shaped cavity in the potato by removing the inner contents. Pour sugar solution of a known concentration(say, 5%) into the cavity. Pierce a pin to mark the level of the sugar solution. Place this potato half immersed in a container with water. Leave it for about half an hour. You will be able to record an increase in the level of sugar solution due to the osmotic movement of water through the semipermeable cell membrane of the cells in the potato.

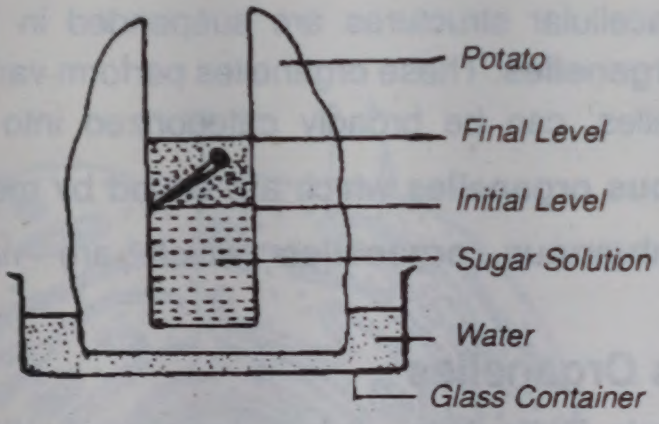


Fig 1.1 Experiment to Demonstrate Osmosis

Conduct a similar experiment taking water inside the potato cup and sugar solution outside. Observe what happens.

Diffusion and osmosis are purely physical processes where substances move from a region of higher concentration to a region of lower concentration. These are passive processes which do not involve expenditure of energy. However, during certain special circumstances the cell takes essential substances against a concentration gradient, where substances from a region of lower concentration move towards a

region of higher concentration. This is an active process and involves expenditure of energy. This is known as **active transport**. The movement of sodium and potassium ions across the cell membrane is an example of active transport.

Sometimes the cell membrane invaginates into the cytoplasm trapping macromolecules, and forming tiny vesicles. These vesicles are pinched off as small vacuoles. In this way macromolecules are selectively taken into the cell. This is known as **pinocytosis,** and the vesicle is known as **pinocytic vesicle.**

Cell Wall : Plant cells have a rigid covering outside the cell membranes, called cell wall. It is chiefly composed of a polysaccharide called cellulose. Sometimes, certain additional substances may be deposited in the cell wall, such as pectin and lignin, for specific purposes. The cell wall allows a free movement of dissolved substances.

Cell Organelles

Electron microscope has revealed some important structures in the cell. These intracellular structures are suspended in the cytoplasm and are called **organelles**. These organelles perform various functions. The cell organelles, can be broadly categorized into

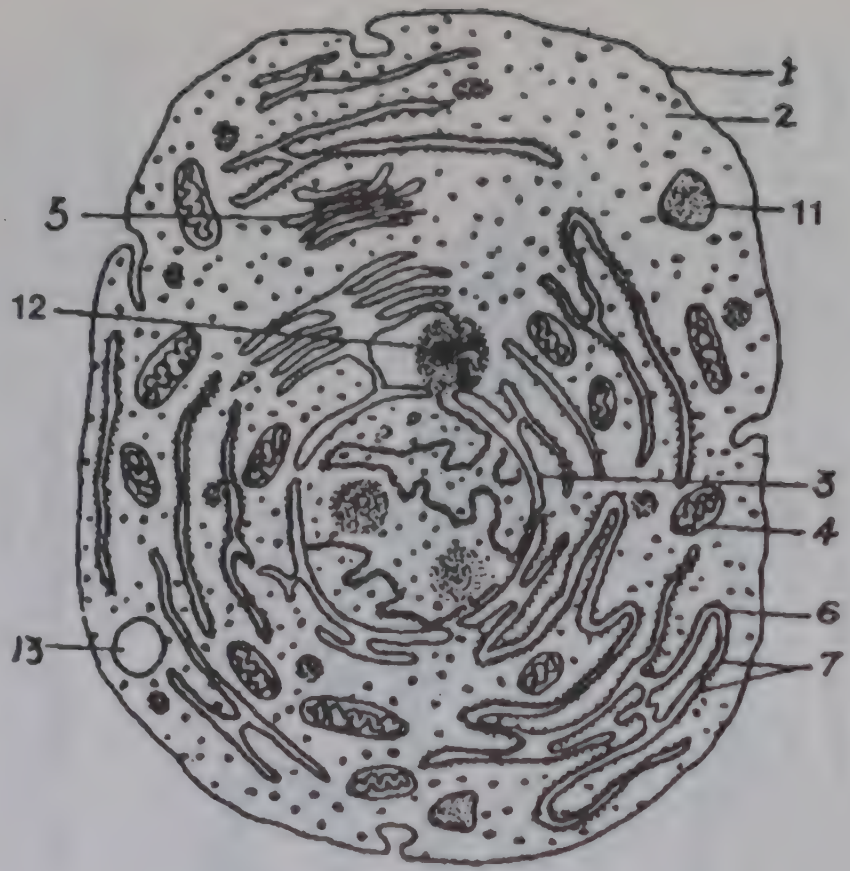
1. **membranous organelles** which are bound by membranes; and

2. **non-membranous organelles** which are not bound by membranes.

Membranous Organelles

1. Endoplasmic Reticulum : It is a network of tubules extending throughout the cytoplasm. It provides a large internal surface for the various chemical reactions of the cell and also acts as an intracellular transport system. The endoplasmic reticulum is said to be **rough** if it is lined by ribosomes facilitating a rapid distribution of various molecules within a cell. When ribosomes are absent, the endoplasmic reticulum is described as **smooth.**

2. Golgi Complex : It is a dense region of the cytoplasm and is made up of stacks of flat cavities lined with smooth endoplasmic reticulum. Certain chemical substances which are to be released from the cell without interfering with the other metabolic process of the cell are often



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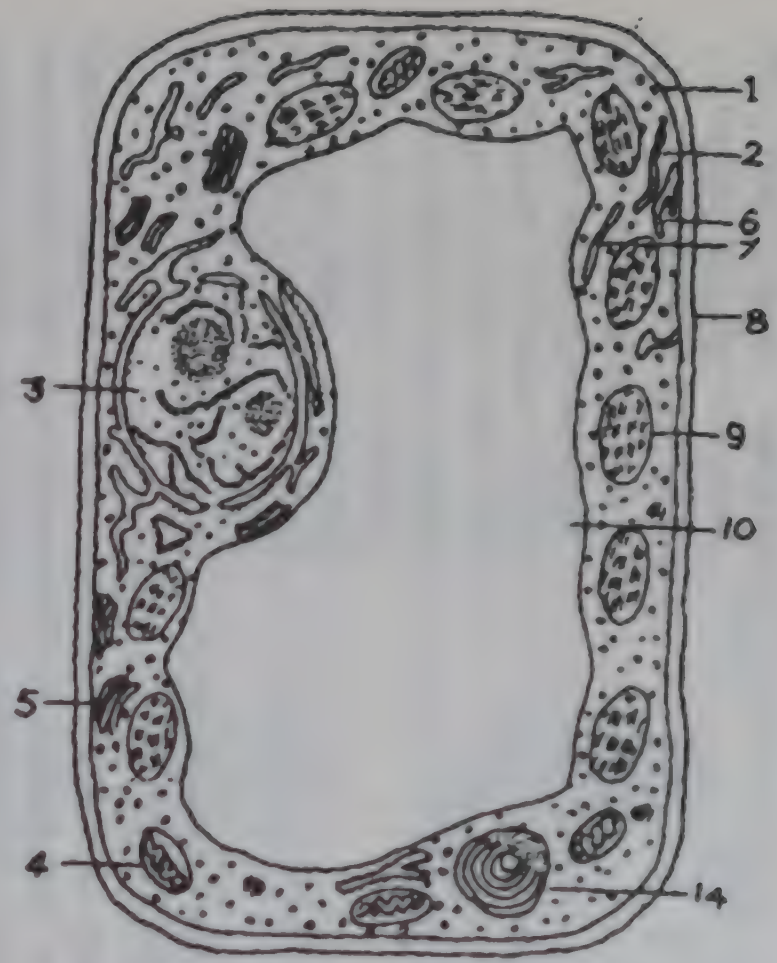

B

1. Cell Membrane
2. Cytoplasm
3. Nucleus
4. Mitochondria
5. Golgi Complex
6. Endoplasmic Reticulum
7. Ribosome
8. Cell Wall
9. Plastid (Chloroplast)
10. Large Vacuole
11. Lysosome
12. Centrosome
13. Small Vacuole
14. Starch Grain

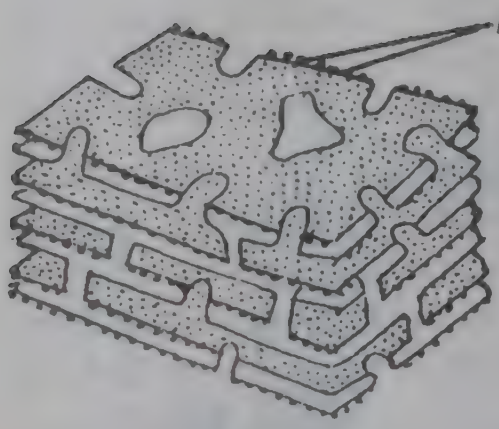

Fig. 1.3. Endoplasmic Reticulum

assembled in the Golgi complex, where they are packed by membranes and are discharged to the outside.

3. Vacuoles : Cell contains many storage areas that are usually known as vacuoles. In plant cells, there is usually a single, large, centrally located vacuole which stores substances such as water, food, minerals and wastes. In animal cells vacuoles may be absent, or if present, may be smaller. The vacuoles are surrounded by a membrane called tonoplast.

4. Lysosomes : A different type of vacuole that is usually found in animal cells is the lysosome. The lysosomes are membranous containers enclosing lytic enzymes. These enzymes destroy unwanted substances. They may even destroy the cell (autolysis) when the cell becomes old or damaged. Hence, the lysosomes are commonly known as "time bombs" or "suicide bags" of the cells. The disappearance of the tail in the tadpole of frog during metamorphosis, is an excellent example of the action of lysosomes.

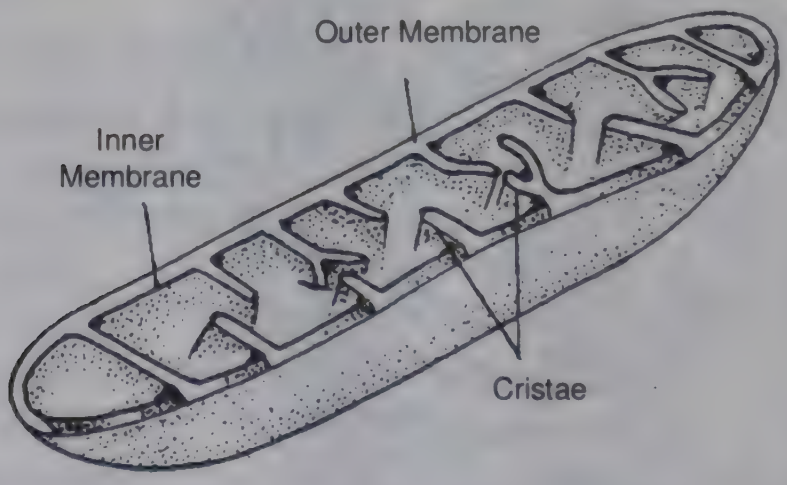

Fig. 1.4. Mitchomdrion (in Section)

Some membranous organelles are involved in the conversion of energy inside the cells. These are the mitochondria and the chloroplasts.

5. Mitochondria : The mitochondria are sasuage–shaped or rod–shaped bodies bound by a double membrane. The outer membrane is straight while the inner membrane is thrown into folds called "cristae". The mitochondria contain enzymes which transform the food energy into metabolically useful form of energy (as adenosine triphosphate – ATP). These enzymes are arranged inside in a sequence that can enhance the rate of breaking of food molecules. Mitochondria are commonly known as "power houses of the cell".

6. Chloroplasts : The chloroplasts represent another set of energy transforming organelles. They are found in the cells of green plants. Like mitochondria, chloroplasts also have a double membrane, but both membranes are smooth and straight. In some areas, these membranes become folded back on themselves to form grana, where chlorophyll molecules are stacked one above the other. The **grana** are also interconnected with one another. The chloroplasts are involved in converting solar energy into chemical energy, by a process known as photosynthesis.

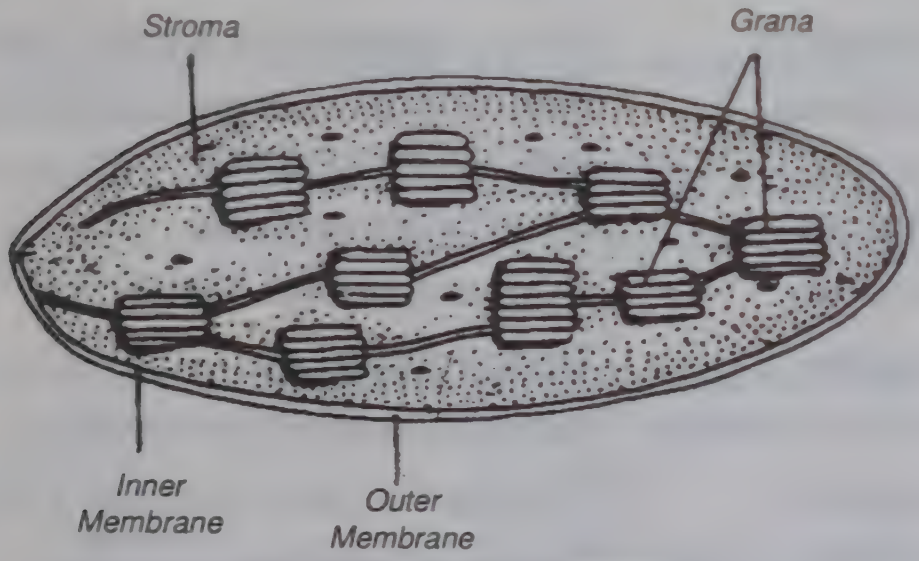

Fig. 1.5. Chloroplast (in Section)

Non-Membranous Organelles

1. Ribosomes : A large number of tiny granular structures found scattered in cytoplasm. These are the ribosomes. They play an

important role in protein synthesis by assembling the amino acids in a particular sequence. They are commonly found on the surface of the endoplasmic reticulum also.

2. Centrioles : These are usually in the animal cells and cells of lower plant. Each centriole is generally composed of two sets of short tubules that are arranged at right angles to each other. During cell division, the spindle fibres converge into the centrioles.

Table 1.1 Cell Organelles and Their Functions

	Organelle	Function
1.	Plasma membrane.	Selects and permits useful substances into the cell
2.	Endoplasmic reticulum	Surface for chemical reactions and transport of substances.
3.	Golgi complex	Associated with secretions.
4.	Mitochondria	Site of cellular respiration and release of energy.
5.	Chloroplasts	Site of photosynthesis in green plants
6	Lysosomes	Destruction of unwanted substances and dead and worn-out cells.
7.	Ribosomes	Site of protein synthesis.
8.	Centrioles	Associated with cell division.
9.	Vacuoles	Storage of materials.
10.	Nuclear membrane	Separates nucleus from cytoplasm.
11	Nucleolus	Provides machinery for protein synthesis.
12.	Chromatin threads	Transfer of hereditary characters.

Cell Inclusions : All the components of cytoplasm do not have a well defined structure. There are a few other components in the cytoplasm which can be grouped together as **cell inclusions** or **ergastic substances.** They are represented by various chemical substances occurring in the form of storage products (starch granules, oil droplets),

or excretory products (crystals of calcium carbonate or calcium oxalate) or secretory products (gums, resins, etc). Such inclusions are common in plant cells.

Nucleus

It is usually the most conspicuous structure in a cell, visible even in a light microscope. It is usually found in the centre. It is spherical and is bound by a double–layered **nuclear membrane** which separates the nuclear components from the surrounding cytoplasm. At certain places the outer layer is continuous with the endoplasmic reticulum. Enclosed in the nuclear membrane is a clear, jelly–like ground substance called **nucleoplasm**. It contains two suspended structures: the **chromatin** and the **nucleolus**. Chromatin is made up of long molecules of deoxyribose nucleic acid (DNA) in association with protein. The chromatin which occurs in the form of a network in a functioning cell, condenses to form shorter structures called **chromosomes**, during cell division. Thus, chromatin contains the blueprints for the construction and maintenance of a cell. The nucleolus (commonly known as little nucleus) is a small, usually spherical structure without a limiting membrance. It is known to contain RNA and a protein. It provides the machinery for protein synthesis.

The important cell components and their functions have been summarized in Table 1.1

1.3 Comparison between Animal Cell and Plant Cell

Some Important differences between an animal cell and a plant cell have been listed in Table 1.2.

Table 1.2 Differences between Animal Cell and Plant Cell

	Animal Cell	Plant Cell
1.	It is surrounded by only a cell membrane.	It is surrounded by both the cell membrane and a cell wall.
2.	Plastids are usually absent.	Plastids are usually present.
3.	Centrioles are usually present.	Present only in motile cells of lower plants.

4.	Vacuoles when present are small and many.	A single large central vacuole is present.
5.	Nucleus is mostly found in the centre.	Nucleus is shifted to an eccentric position due to the vacuole.

EXERCISES

I. Answer the following questions :

1. Write a brief note on cell membrane.
2. Describe the structure and function of mitochondria.
3. List the functions of the following cell organelles :

   (i) Endoplasmic reticulum (ii) Golgi complex
   (iii) Ribosomes (iv) Lysosomes
   (v) Chloro plast (vi) Centrioles
4. Describe the structure of the nucleus of a cell.
5. Draw a neat diagram of a typical animal cell as seen under and electron microscope.
6. Draw a neat labelled diagram of a typical plant cell as seen under an electron microscope.

II. Name the following :

1. Power houses of cell
2. Suicide bags of the cell
3. Storage areas of the cell
4. Organelles of photosynthesis
5. Protein factories of the cell
6. Structural and functional unit of life

III. Write the differences between :

1. Organelle and Organ

2. Cell membrane and Cell wall
3. Diffusion and Osmosis
4. Active transport and Passive transport
5. Lysosomes and Ribosomes
6. Animal cell and Plant cell

IV. **Fill in the blanks :**

1. Cell membrane is described as a _____membrane.
2. Osmosis in a cell refers to the movement of_____molecules
3. The process by which a macromolecule is taken into a cell is called _____
4. The membrane surrounding a vacuole is called _____
5. The organelles which play an important role during cell division are _____
6. The Chemical substances occurring in a cell in various forms, such as storage or secretory or excretory products, are known as _____
7. Chromatin is composed of _____
8. The nucleus is also known as _____

CHAPTER 2

CELL DIVISION

2.1 Introduction

Cells increase in number by a process called **cell division**. During cell division a cell divides into two passes its genetic information to the next generation. In unicellular organisms cell division brings about multiplication of individual, while in multicellular plants and animals, cell division leads to growth, repair, maintenance and reproduction.

There are two major types of cell division, namely (1) Mitosis and (2) Meiosis.

2.2 Mitosis

It is the most common type of cell division. In higher plants and animals mitosis occurs in vegetative cells. Hence, it is known as **somatic cell division.** During mitosis parent cell divides into two daughter cells, each with the same number of chromosomes as found in the parent cell. Therefore, mitosis is also known as **equational division.**

There are two major divisions during mitosis; the division of the nucleus or **karyokinesis**; and the division of the cytoplasm or **cytokinesis**.

Just before a cell divides, it prepares, itself for the process. There is active synthesis and storage of food inside the cell. This preparatory phase is known as **interphase**. It is during this period that DNA undergoes replication in the nucleus. Interphase is also the stage between two successive mitotic division.

Once division is initiated, a number of important changes take place in the cell. These changes can be conveniently studied under four phases; Prophase, Metaphase, Anaphase and Telophase.

Prophase : It is the longest phase during karyokinesis. Several significant changes take place during prophase. The chromatin network breaks and the threads become more distinct, short and thick. They are now called **chromosomes**. As prophase advances, each chromosome appears to be made up of two parallel strands held together at a point

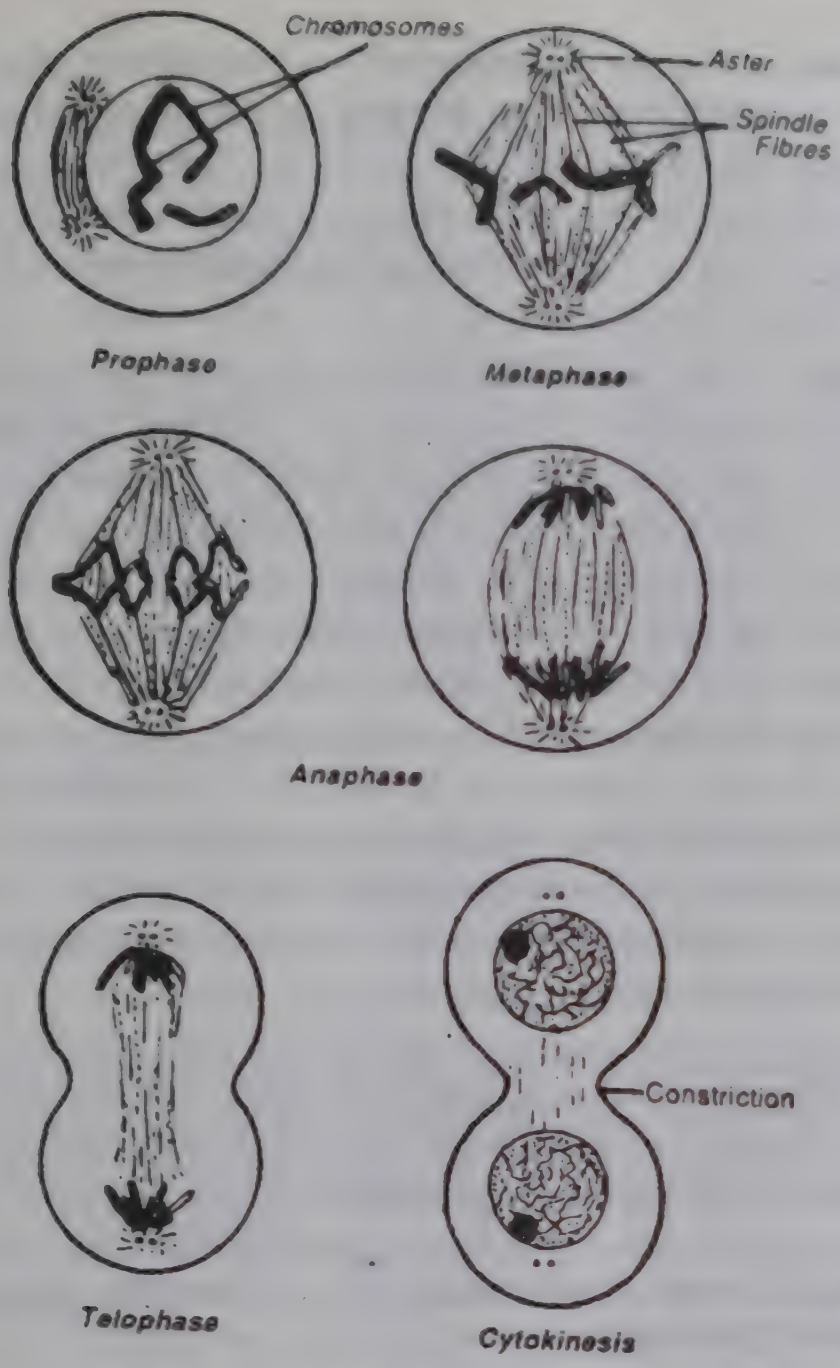

Fig. 2.1. Stages during Mitosis in an Animal Cell

called centromere. The parallel strands represent the **sister chromatids.** Meanwhile, the centrioles develop cytoplasmic fibres and move apart to take positions at opposite poles of the cell. They appear star–like and are known as **asters**. Asters are not seen in plant cells. Tiny cytoplasmic fibres called spindle fibres make their appearance radiating from one after another. Prophase comes to an end with the disapprearance of nucleolus and nuclear membrane. The loss of nuclear membrane sets the chromosomes free in the cytoplasm.

Metaphase : It is the shortest phase of karyokinesis. During meto phase the chromosomes move towards the centre of the cell where they arrange along the equatorial plane. The lining up of the chromosomes marks the plane along which the cell divides. This arrangement ensures that each resulting daughter cell receives one set of chromosomes.

Anaphase : The centromere, which holds the two chromatids of a chromosome together, divides into two. The two chromatids of a chromosome repel and begin to move away to opposite poles. Some of the spindle fibres attached to the centromeres pull the centromeres towards their respective poles. Between the two sets of daughter chromosomes which move to opposite poles, a new set of cytoplasmic fibres, knows as "inter–zonal fibres", develop.

Telophase : It is the final phase of karyokinesis in which a daughter nucleus is formed at each pole of the cell. On reaching the polar ends of the cell the daughter chromosomes become dense. A nucleolus is organized and a nuclear membrane formed arround each set of chromosomes, resulting in the formation of two identical daughter nuclei. All the cytoplasmic fibres disappear.

Simultaneously with telophase, the cell starts dividing into two. This process is known as **cytokinesis.** In animal cells it occurs by a pinching–in process, as if a string is tightened around the middle of a cell. This groove is called **cleavage furrow.** In plant cells the cytoplasmic division is marked by the appearence of a **cell plate.** It begins as a faint line at the equator gradually develops into a cell wall, dividing the parent cell into two daughter cells.

Why is mitosis necessary?

The main purpose of mitosis is the equal distribution of chromosomes to the two resulting cells. It provides a complete set of genetic information to each daughter cell, by maintaining the chromosome number constant. It is essential for the growth of an organism and also for the repair and regeneration of body parts. The healing of wounds is primarily because of mitotic division. Mitosis brings about multiplication in unicellular organisms.

2.3 Meiosis

In somatic cells, the chromosomes normally occur in pairs. Of the two chromosomes of a pair, one comes from the male parent and is known as **paternal chromosome** and the other comes from the female parent and is known as **maternal chromosome**. For every paternal chromosome there is an exactly similar maternal chromosome. These two together constitute a pair of **homologous chromosomes**. Thus, a typical somatic cell contains two sets of chromosomes; a paternal set and a maternal set. Germ cells, however, contain a single set of chromosomes. Thus, there are two types of chromosome numbers among sexually reproducing organisms; the chromosome number characteristic of somatic cells, called the **diploid** number (two sets); and the chromosome number characteristic of germ cells, called the **haploid** number (single set). The reduction in the number of chromosomes from a diploid to a haploid condition is known as **meiosis**. It is also known as **reduction division**.

Meiosis consists of two divisions that take place one after the other. The first is a reduction division and the second, as equational division. The two divisions are called meiosis I and meiosis II.

Meiosis I is the actual reduction division in which the chromosome number is reduced to half. It involves a sequence of events in which the two homologous chromosomes separate into the resulting daughter cells. The sequence of events during meiosis I can be divided into four phases for the sake of convenience, namely, prophase I, metaphase I, anaphase I and telophase I.

Prophase I : Most of the events in prophase I of meiosis are similar to those of mitosis. The chromatin material coils and thickens into chromosomes, the nucleolus disappears, the nuclear membrane disintegrates and the spindle apparatus is formed. During prophase I, the homologous chromosomes pair with each other. This pairing of homologous chromosomes is known as **synapsis** (Pairing does not occur during mitosis). The pair represents a **bivalent.** Each chromosome in the pair splits vertically into two chromatids. The four chromatids of a homologous pair represent a **tetrad**. The inner chromatids of the pair exchange segments between them which is known as **crossing over.**

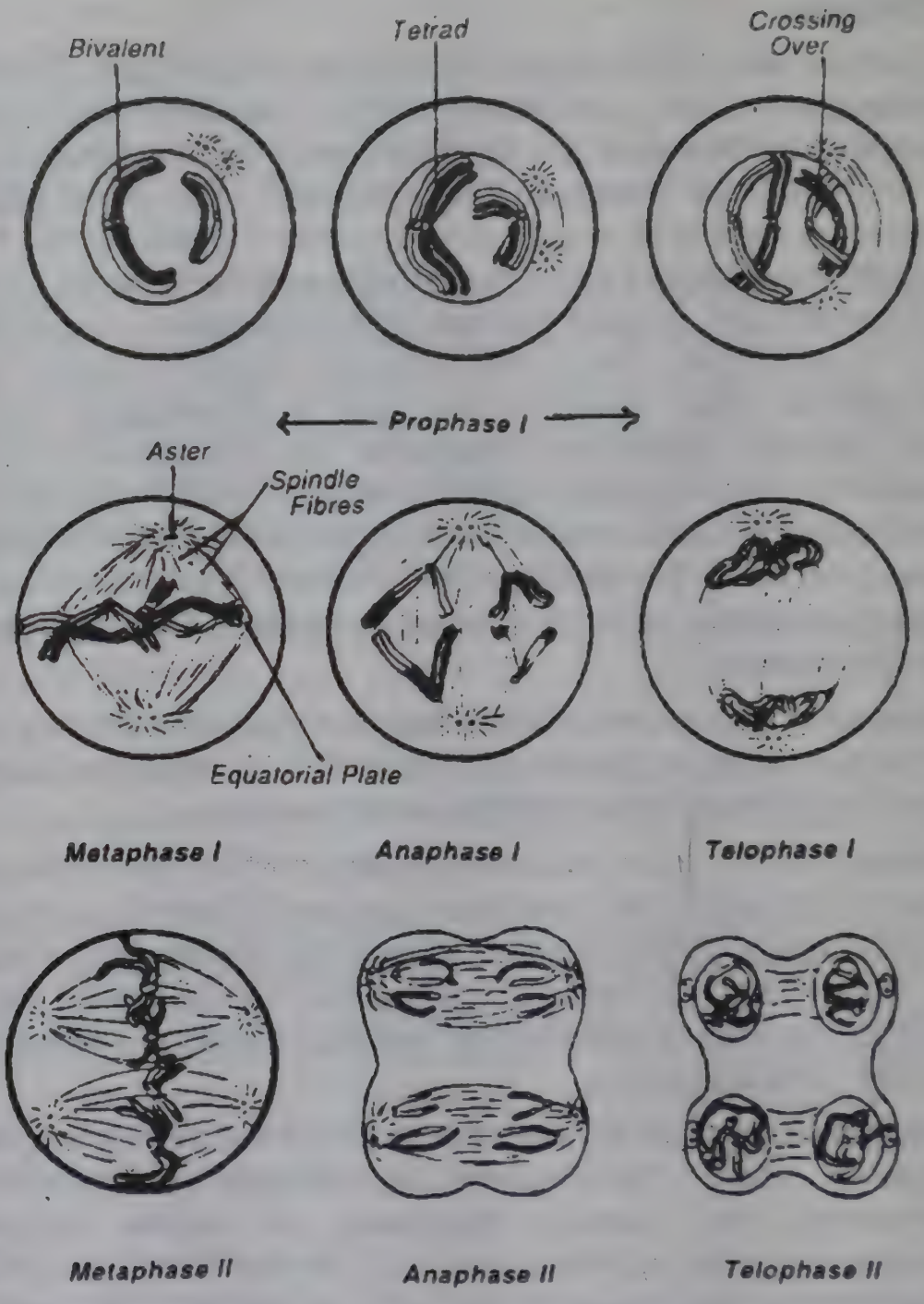

Fig. 2.2. Stages during Meiosis in an Animal Cell

Metaphase I : During this phase the chromosomes move towards the equatorial plane of the cell. They come to lie equally distributed on either side of the equator, forming two parallel metaphase plates. One of these plates is formed by one set of chromosomes while the other by their homologues.

Anaphase I : During this phase the homologous chromosomes separate and move to opposite poles. The centromeres do not divide during this stage.

Telophase I : It consists of changes that return the cell to an interphase condition. The chromosomes uncoil and become long and thin threads, and the nuclear membrane and a nucleolus reappear at each pole. Simultaneous with the formation of daughter nuclei, the cytoplasm also divides and two haploid daughter cells are formed.

Meiosis II follows simultaneously in both the haploid daughter cells. There may or may not be a gap of time between the divisions. However, the chromosomes do not duplicate as they have already done so in the interphase earlier to prophase I. Meiosis II also has four phases: prophase II, metaphase II, anaphase II and telophase II.

The changes taking place during **prophase II** are similar to those during the prophase of mitosis. Spindle fibres are formed between the two asters and the nuclear membrane disappears, leaving the chromosomes free in the cytoplasm. During **metaphase II** the chromosomes arrange along the equator of the cell. The spindle fibres attach to the centromeres. **Anaphase II** differs from anaphase I in that, here, the centromere divides into two and the two chromatids of each chromosome move to opposite poles. During **telophase II** there is nuclear reorganization, ultimately resulting in the formation of four daughter cells.

Why is meiosis necessary?

During sexual reproduction, two gametes, a male and a female, fuse to form a single cell called **zygote.** It is a diploid cell from which all the cells of the future organism are formed. If the gametes are also diploid, the zygote will receive four sets of chromosomes instead of two sets. Hence, the gametes which undergo fusion must **be haploid**, if they have to produce a diploid zygote. Thus, meiosis becomes necessary during the formation of gametes so that the chromosome number of the species in successive generation remain constant. Meiosis produces cells that have one set of chromosomes, therefore, when fertilization occurs, the resulting zygote will have the same number of chromosomes found in the parent. The other important aspect of meiosis is that it brings about genetic variations due to the exchange of genetic material during crossing over.

2.4 Comparison between Mitosis and meiosis

Differences between mitosis and meiosis are shown in table 2.1.

Table 2.1 Differences between Mitosis and Meiosis

	Mitosis	Meiosis
1.	It occurs in all the cells of the body–somatic and reproductive cells.	It occurs only in reproductive cells.
2.	It occurs almost throughout life in some cells.	It occurs only during the formation of gametes.
3.	It involves a single nuclear division.	It involves two successive nuclear divisions.
4.	Two daughter cells are formed from each parent cell.	Four daughter cells are formed from each parent cell.
5.	Chromosome number of the daughter cells is equal to that of the parent cell.	Chromosome number of the daughter cells is half that of the parent cell.
6.	There is no pairing of homo logous chromosomes; hence there is no chance of crossing over.	Homologous chromosomes undergo pairing and almost always there is crossing over.

EXERCISES

I. Answer the following questions :

1. Name the types of cell division and the cells in which these divisions occur.
2. Describe the prophase of mitosis.
3. Outline the changes that take place during the following phases of mitosis : (i) Metaphase (ii) Anaphase.
4. What is the need for mitosis?
5. Why is meiosis called reduction division?

. Describe the events occuring during prophase I of meiosis.

. What is the need for meiosis?

I. Name the following :

. The point at which the two parallel strands of a chromosome are held together.

. Preparatory phase of cell division.

. Division of the nucleus.

. Division of the cytoplasm.

. Pairing of homologous chromosomes.

. Exchange of segments between homologous chromosomes.

II. Write the differences between :

. Chromosomes and Chromatids.

. Somatic cells and Germ cells.

. Prophase of mitosis and Prophase of meiosis I.

. Mitosis and meiosis.

. Meiosis I and Meiosis II.

. Cytokinesis in an animal cell and a plant cell.

. Diploid and Haploid chromosome numbers.

V. Fill in the blanks :

. Mitosis occurs in _____cells.

. Mitosis is also known as _____division.

. During _____the chromosomes arrange along the equator.

. Centromeres split during _____.

. Meiosis is also known as _____.

. Meiosis occurs in _____cells.

. During meiosis, nucleus divides _____.

. Meiosis results in the formation of _____daughter cells.

CHAPTER 3

LEVELS OF ORGANIZATION

3.1 Introduction

There are living beings around you : in water, in air, on the soil and below the soil. Some are microscopic. Others, like the elephant, the whale or the trees, are considerably bigger than you. Living organisms show variations not only in size and structure, but also in appearance and in ways of life. This diversity among living organisms suggests that there are different levels of organization, both in plants and animals.

3.2 Hierarchy of Organization

Look at Fig. 3.1. You see some representatives of the most primitive group of animals, called protozoans. The common feature in these examples, **Amoeba**, **Euglena** and **Paramecium**, is that the body is made of a single cell. This cell is able to perform all the vital life processes such as respiration, digestion, excretion and reproduction.

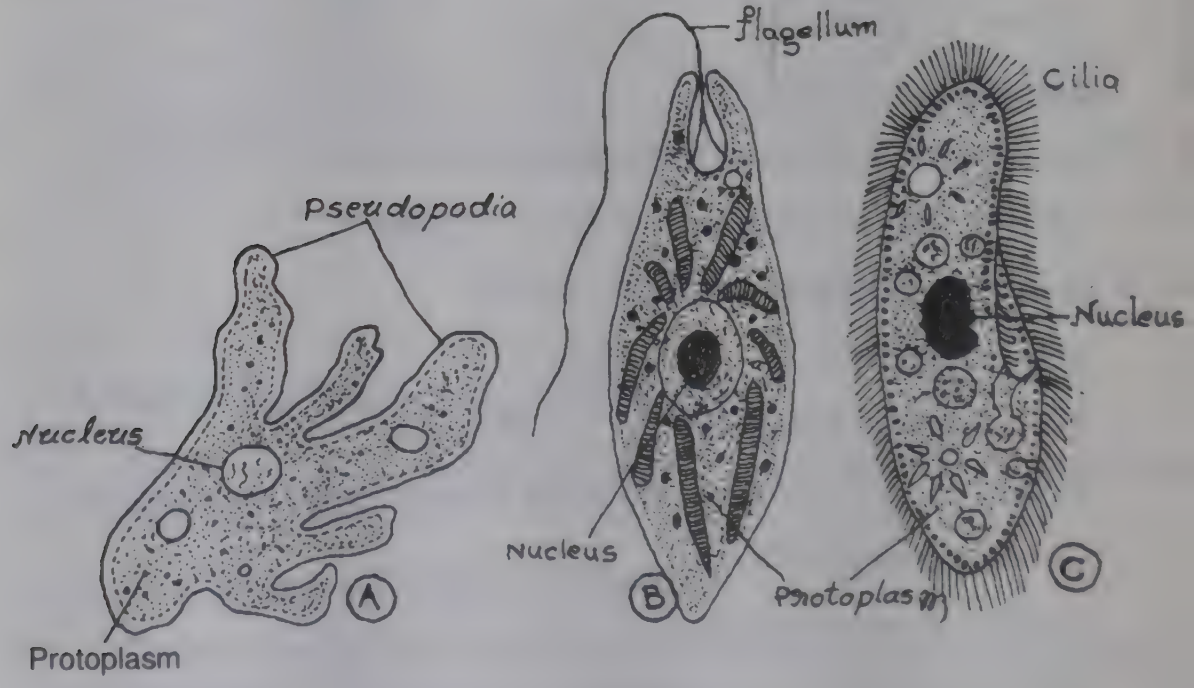

Fig. 3.1. Common Unicellular Organisms.
(A) Amoeba; (B) Euglena; (C) Paramecium.

Such organisms are described as **unicellular organisms** or **acellular organisms**.

There are some unicellular organisms which form colonies, such as *Volvox*, *Pandorina* and *Eudorina* (Fig. 3.2). These colonies consist of varying numbers of simple flagellated cells embedded in a sphere of mucilage. These organisms are essentially unicellular, all the cells are identical and there is no structural connection between them. In Volvox, however, a small number of cells in the colony are specialized for reproduction and these cells become connected to one another by protoplasmic strands. This level of organization is known as **colonial organization.**

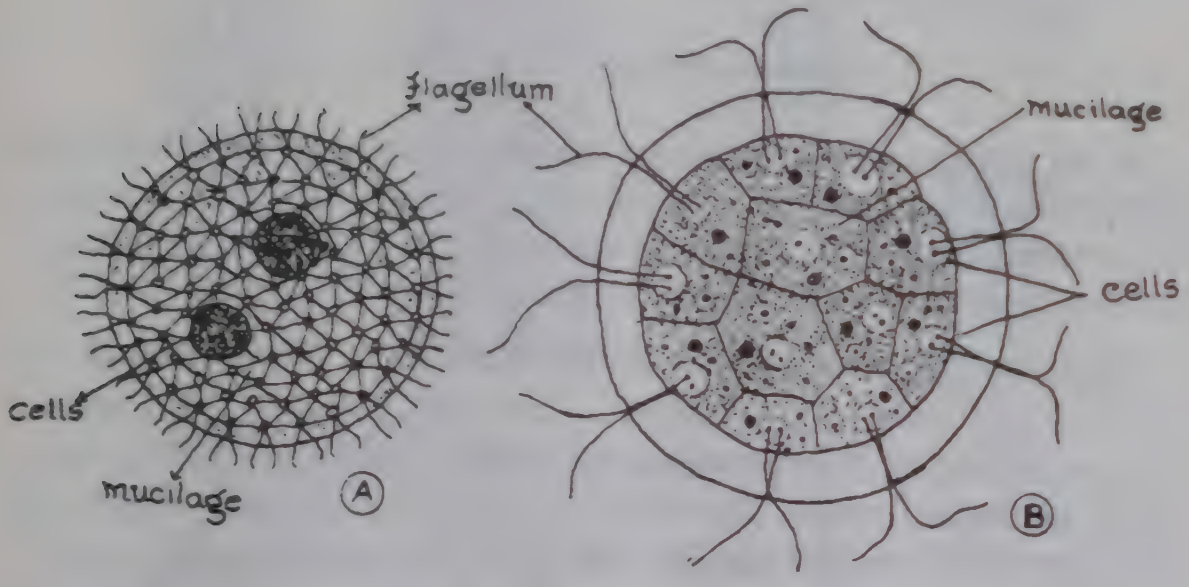

Fig. 3.2. Colonial Unicellular Organisms : (A) Volvox; (B) Pandorina

Some organisms are composed of cells that are functionally independent from one another. This is seen in sponges. A simple sponge such as the one shown in Fig.3.3 consists of five types of cells: flat epithelial cells, hollow pore cells, flagellated collar cells, skeleton–secreting mesenchyme cells and wandering amoeboid cells. These cells are functionally independent of one another and can exist on their own or in small isolated groups. This level of organization is known as **cellular level of organization**.

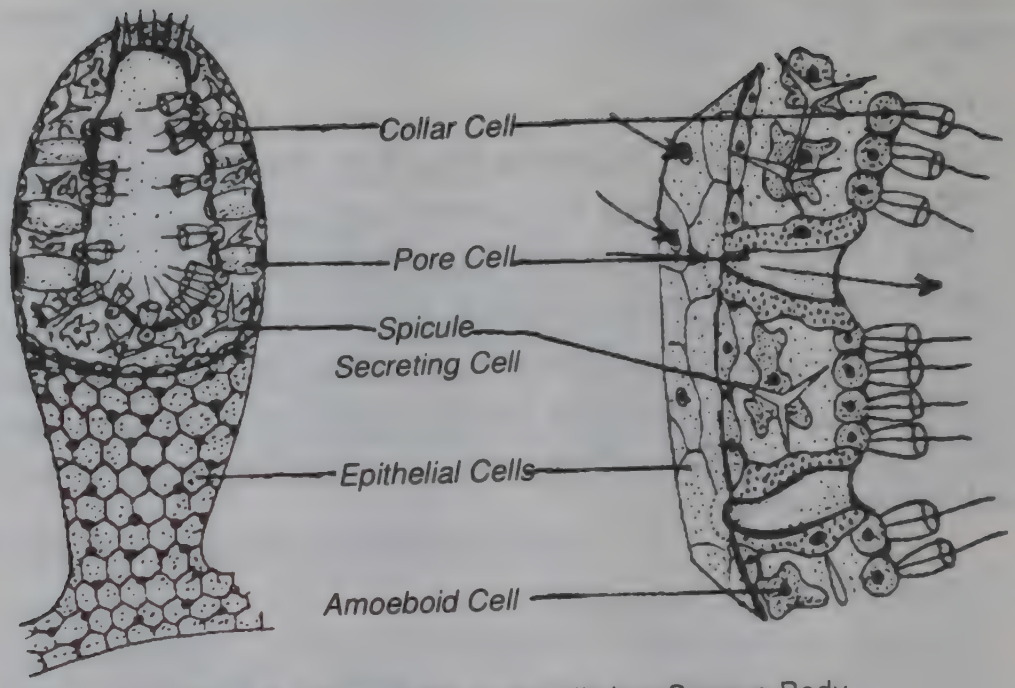

Fig. 3.3. Different Types of Cells in a Sponge Body

As we go higher up in the ladder of animal evolution, we see that the cells of the body become specialized to perform particular functions. This change resulted in the formation of **tissue.** A tissue is a group of cells having a common origin and structure, performing similar functions.

There are different types of tissues in animals. The cells that line the skin are meant for protection. The cells that line the intestine are specialized for digestion and absorption. These cells form a tissue called **epithelial tissue**. The cells that specialize in body movement make up the **muscular tissue**. The cells that form internal skeleton make up the **connective tissue**. The cells that control and co-ordinate the body functions form the **nervous tissue**.

As the evolution of animals continued, we see the formation of **organs**. Organs are body units composed of different types of tissues that operate together to perform a particular function. The stomach, liver, heart, brain and gonads are some examples of organs.

Further evolution resulted in the collection of organs that perform common functions to form **organ systems**. A higher animal such as frog has different organ systems such as digestive system, circulatory system, respiratory system, reproductive system and nervous system.

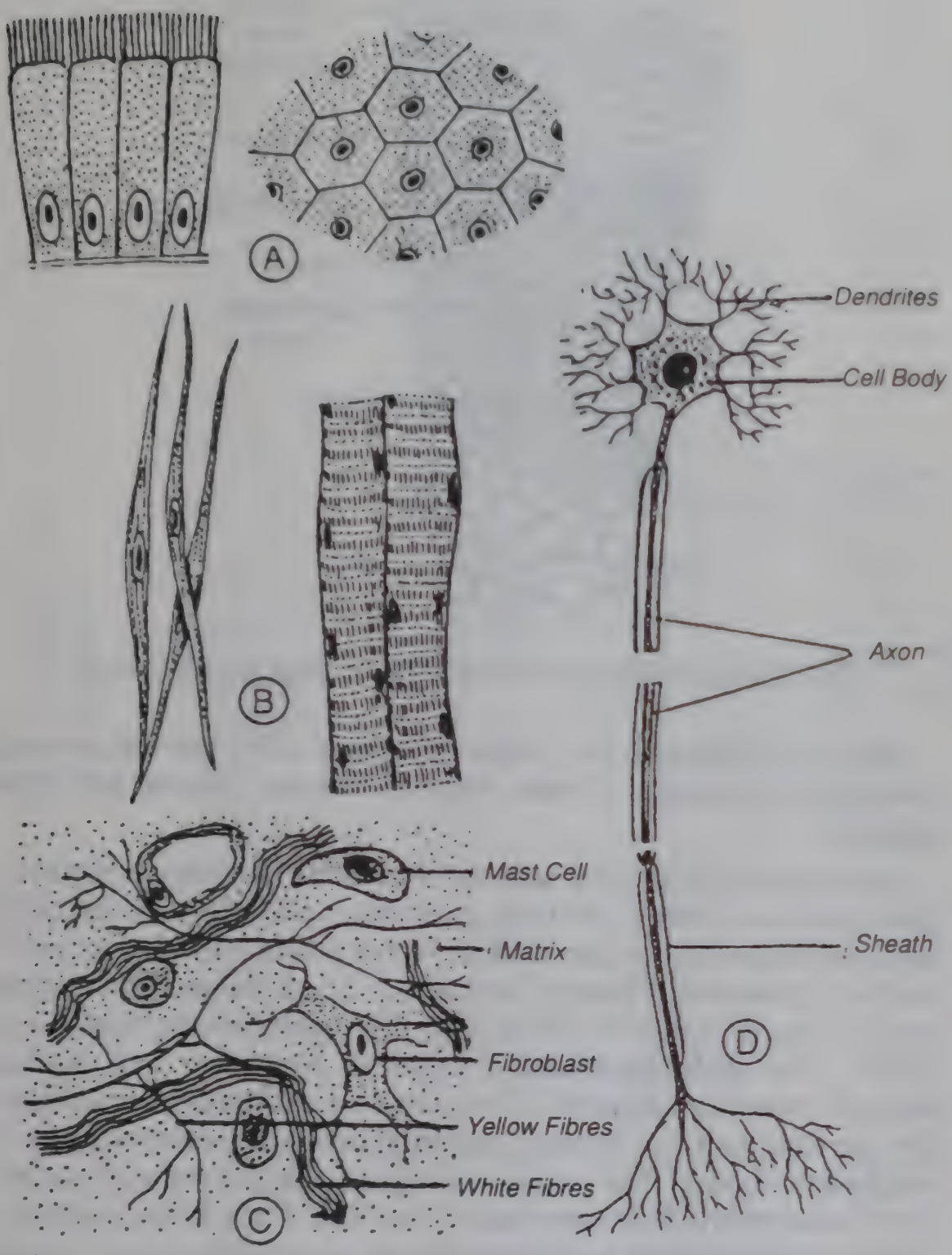

Fig. 3.4. Types of Animal Tissues : (A) Epithelial Tissues; (B) Muscular Tissue; (C) Connective Tissue; (D) A Neuron : Unit of Nervous Tissue

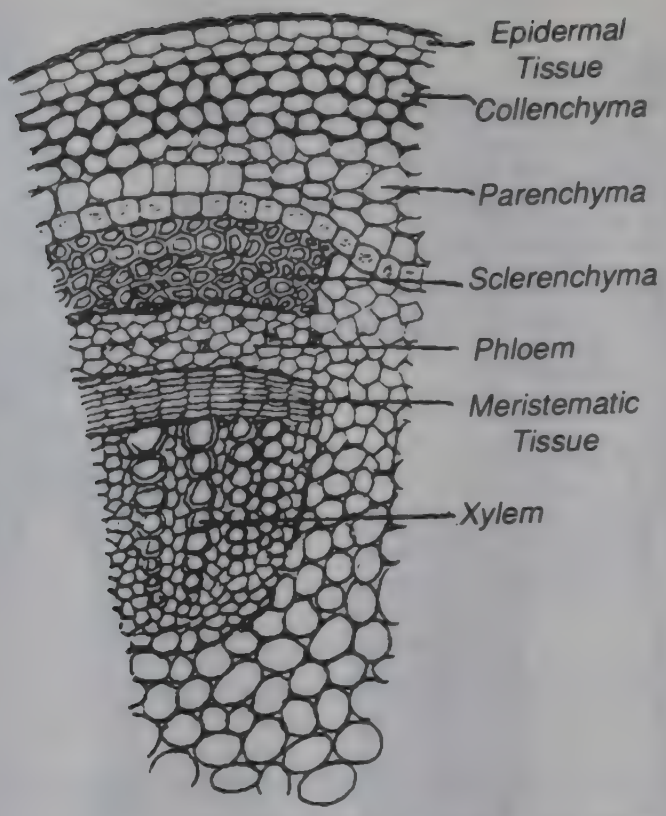

Fig. 3.5. Section through the Stem of a Plant to Show Types of Tissues

Thus, organization in living organisms, particularly animals, shows a hierarchy of sequence : cells, colonies, tissues, organs and organ systems.

How do plants fit into this scheme? Plants are generally organized at the tissue level. Most of the body functions in plants are carried out by cells and tissues rather than organs. Higher plants may show organs in the form of leaves and flowers. Look at Fig. 3.5. It shows some common types of tissues found in a plant body. The **meristematic tissue** is for growth. The **epidermal tissue** is meant for protection. The **vascular tissue** is meant for conduction of food and water. There are also tissues like **parenchyma** for storage, **collenchyma** and **sclerenchyma** for mechanical support. The absence of organ system in plants is because of the basic difference in their mode of nutrition. A plant manufactures its food by photosynthesis and does not need an elaborate organ system.

Now you know what the levels of organization are in living organisms and why there are so many types and varieties of living organisms. Al the living organisms that belong to a particular species, found in particular area, together constitute a population. Thus in a given place

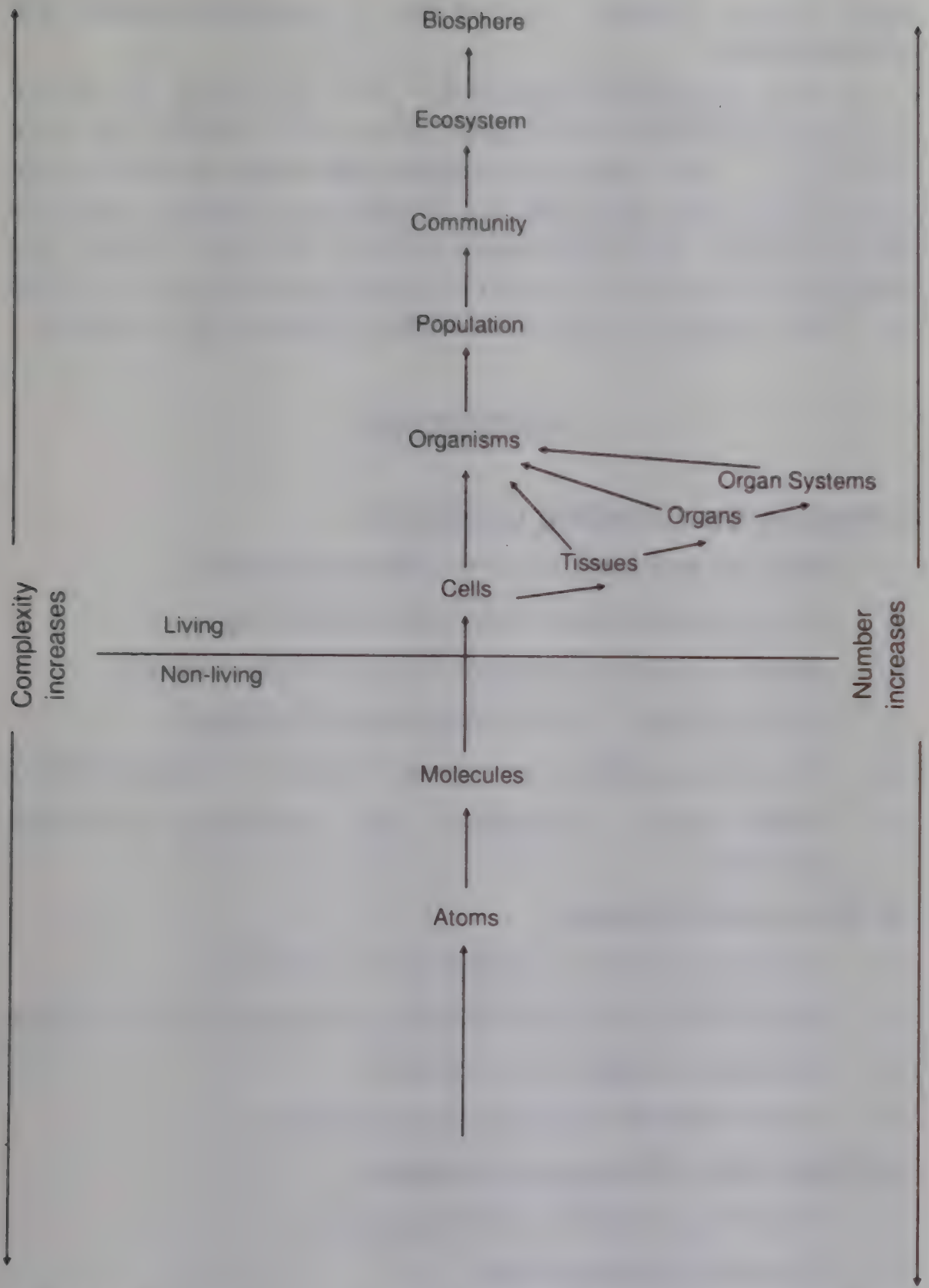

Fig. 3.6. Schematic Representation of the Levels of Organization in the Living World

there maybe different populations of animals, plants and micro–organism.

All these populations together–the plant community, the animal community, the bacterial community and so on–represent the biotic community. The entire biotic community found in a particular geographical area, along with the physical environment, represents the ecosystem. In an ecosystem there is interaction between the living and non–living components. The part of the earth that is inhabited by a wide variety of living communities represnts the biosphere.

EXERCISES

I. Answer the following questions:

1. What are acellular organisms? Give two examples.
2. What is colonial organization? Give an example.
3. Describe cellular organization taking a suitable example.
4. Define a tissue. List the primary tissues in animals.
5. How do plants differ from animals in their level of organization.
6. Define terms : Population, biotic community, ecosystem, biosphere.

II. Name the following :

1. Animal tissue which is responsible for movement
2. Animal tissue which controls and co-ordinates the body functions.
3. Plant tissue responsible for growth.
4. Part of the earth containing living organisms.

III. Write the differences between :

1. Acellular and Cellular level of organization.
2. Population and Community.

IV. Fill in the blanks :

1. Paramecium is an example of_____organism.
2. In higher animals_____tissue forms the endoskeleton.
3. Plants mostly exhibit_____level of organization.
4. A collection of different populations of organism is called_____

CHAPTER 4

LIFE PROCESSES

4.1 Introduction

We have seen in the previous chapter that there is an astonishing diversity among living organisms. Yet there is one feature that is common to all of them. As long as any organism is alive, it must continue releasing and using energy for its various life activities. In this chapter let us examine some of the vital life processes taking place in living organisms.

4.2 Nutrition

The first and foremost requirement of living organisms is **food**. There are basically two groups of organisms with respect to food requirement; those that can synthesize their own food material, called **autotrophs**; and those that depend on others for their food since they cannot manufacture their own, called **heterotrophs**. The most important groups of autotrophs are the blue–green algae and the green plants. There are a few types of bacteria which can use chemical sources of energy for synthesizing organic food. They are the **chemosynthetic** bacteria. The heterotrophs, on the other hand, feed on organic molecules synthesized by other organism. A majority of the bacteria, fungi and other non–green plants and all animals are heterotrophs, which ultimately depend upon photosynthetic organisms for their existence. Therefore, the nutritional requirements of autotrophs and heterotrophs are quite different.

The mode of nutrition in a green plant is described as holophytic. It involves a process by which organic compounds are synthesized from inorganic substances in the presence of sunlight. This process is known as **photosynthesis**.

Photosynthesis occurs in all the green parts of a plant body, particularly in the green leaves. Green leaves contain a group of cells called **mesophyllcells** that contain chloroplasts. Choloroplasts contain the green pigment **chlorophyll** which can trap solar energy and convert it into chemical energy.

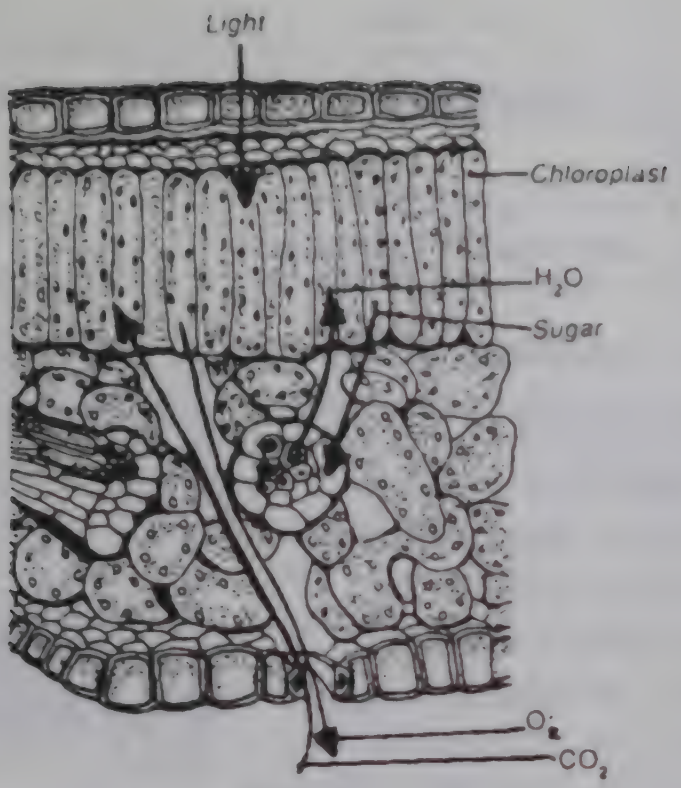

Fig. 4.1 Section through a Leaf

Photosynthesis involves the manufacturing of sugars using carbon dioxide and water as raw materials, in the presence of sunlight and chlorophyll. The overall reaction of photosynthesis can be represented as

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Mechanism of Photosynthesis

In photosynthesis, there are two phases, namely, **light reaction** and **dark reaction**. The light reaction needs light and it takes place in the grana region of the chloroplast. The dark reaction does not require light and it takes place in the stroma region of the chloroplast.

Light Reaction : It is also called the photochemical reaction. During this reaction light energy is converted into chemical energy and oxygen is liberated.

Dark Reaction : It is also called Calvin cycle. It depends upon the products of light reaction and the presence of carbon dioxide

During this reaction carbon dioxide is reduced to a carbohydrate.

Activity 4.1 : To Demonstrate the Liberation of Oxygen during Photosynthesis

Materials : A funnel, a graduated tube, a beaker, water and twigs of Hydrilla (an aquatic plant).

Procedure : The beaker is filled with water. In the broad end of the funnel the twigs of Hydrilla plant are kept and the funnel is inverted in the beaker. A graduated test–tube filled with water is inverted on the stem of the funnel. The set–up is left in sunlight for a few hours.

Observation : Bubbles of gas come out of the plant and get collected in the test–tube displacing the water. When a burning splinter is introduced into the test–tube, it burns more brightly.

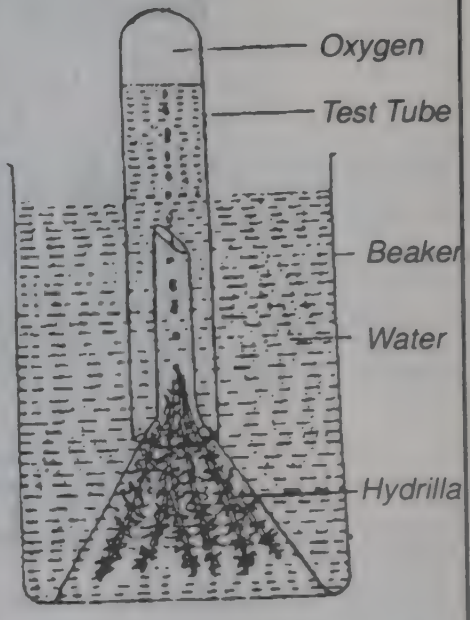

Fig. 4.2 Experiment to Show that Oxygen is Liberated.

Inference : The gas collected in the test–tube is oxygen.

Activity 4.2 : To Show that Carbon Dioxide is Necessary for Photosynthesis (Mohl's Half Leaf Experiment)

Materials : A potted plant, a wide–mouthed bottle, split cork and potassium hydroxide solution (for absorbing carbon dioxide)

Procedure : The potted plant is destarched by keeping it in dark for about 24 hours. One suitable leaf of this plant is introduced half into a wide–mouthed bottle containing potassium hydroxide solution, with the help of a split cork. The set–up is left in sunlight for a few hours.

The leaf is then taken out and tested for starch.

Observation : The half of the leaf that was inside the bottle gives a negative result while that half which was outside gives a positive result.

Contd. on p. 31

Inference : Carbon dioxide was not available inside the bottle. Hence no starch could be manufactured.

Starch Test :

- ★ The experimental leaf is boiled in water to kill the cells.
- ★ It is then gently warmed in alcohol to extract chlorophyll.
- ★ The bleached leaf is tested with a few drops of iodine.
- ★ A characteristic blue or black colour indicates the presence of starch as a result of photosynthesis.

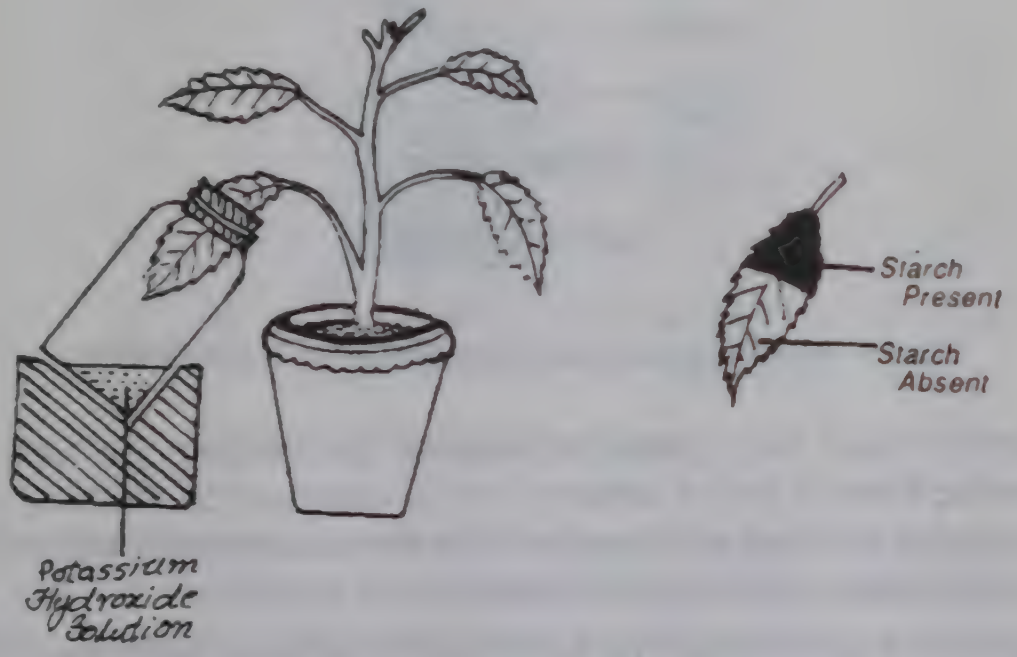

Fig 4.3 Experiment to Show that CO_2 is Necessary for Photosynthesis

Nutrition in Animals

Animals cannot manufacture their own food. They feed on food prepared by plants or on other animals that feed on plants. Hence, animals are described as **heterotrophs.**

The mode of nutrition in animals is known as **holozoic** indicating that there is intake of solid organic food. In higher animals there is an organ system that is responsible for this function called **digestive system**. It consists of the alimentary canal through which the food passes and some associated structures such as salivary glands, liver and pancreas. The

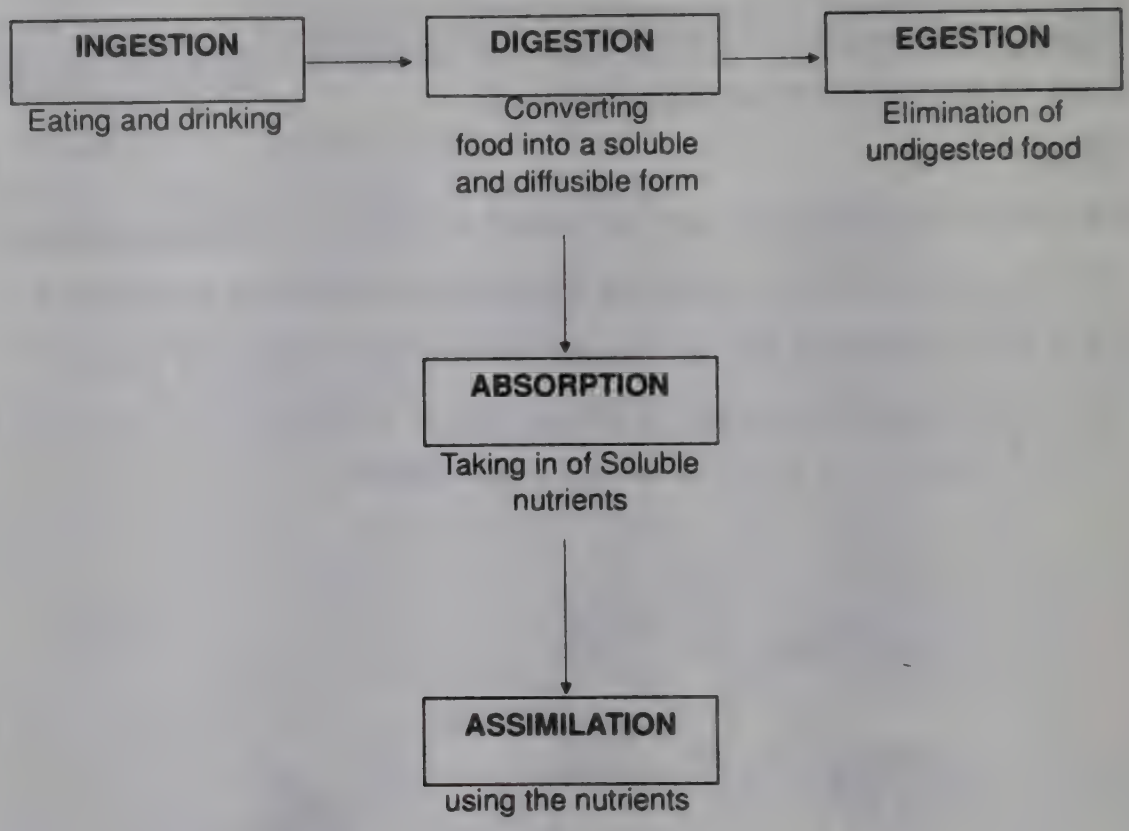

Fig. 4.4. Scheme Showing the General Pattern of Animal Nutrition

alimentary canal has specialized regions for handling the food and converting it into a form in which it can be absorbed by the body cells. This process is known as **digestion**. The associated structures produce some secretions which help in the process of digestion.

Look at the different parts of the human digestive system (Fig.4.5). Of these parts, only the buccal cavity, the stomach and the small intestine are involved in the process of digestion. Some of the parts, like oesophagus, are involved in mechanical movement of the food, while parts of the small intestine absorb the digested food. The large intestine is mainly involved in the absorption of water and elimination of undigestd food.

Digestion in man is of two types:

(1) **Mechanical digestion** which involves breaking up of the larger particles of food into a fine paste using the tongue and the teeth. This process is also known as **chewing** or **mastication**.

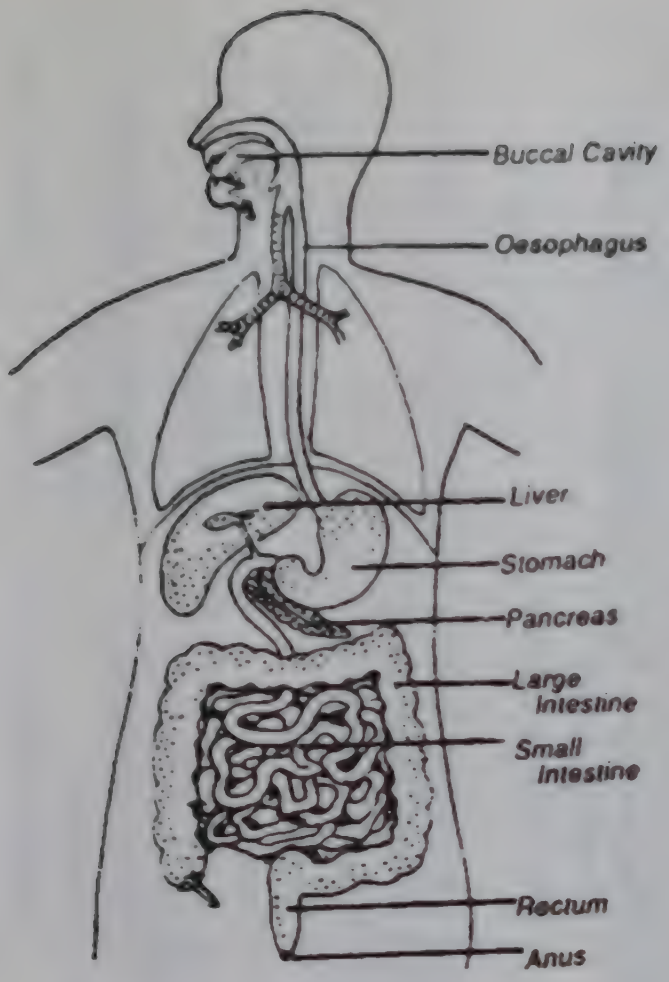

Fig. 4.5. Human Digestive System

(2) **Chemical digestion** which involves the hydrolysis of food into a simpler form by the action of biological catalysts called **digestive enzymes.** These enzymes are present in the secretions of salivary glands, gastric glands (in the stomach), intestinal glands (in the small intestine) and the pancreas.

Table 4.1 summarises the various processes involved in nutrition in man.

4.3 Respiration

Respiration is a process in which the energy which is trapped in the food is released by oxidation. The food that is either manufactured or consumed by an organism cannot instantaneously release energy. It has to be oxidised or burnt in order to obtain energy for various activities.

Table 4.1 Summary of Digestion in Man

Region of the Digestive System	Digestion of Food			Substrate	Product
Mouth (Buccal Cavity)	Food is taken in (Ingestion)	Chewing with teeth and tongue	*Enzyme* Salivary amylase (from salivary glands)	Starch	Maltose
Oesophagus	Rhythmic move-ments pass the food into stomach	Peristalsis			
Stomach	Contractions force food into small intestine	Churning Peristalsis	Pepsin Rennin	Proteins Soluble milk protein	Polypeptides Insoluble curds
Small Intestine		Fat emulsification (from bile juice)	Protein-digesting enzymes Carbohydrate-digesting enzymes. Fat-digesting enzymes (from intestinal glands and pancreas)	Polypeptides Starch and complex sugars Fats	Aminoacids Simple sugars Fatty acids and glycerol

(contd.)

Table 4.1 Summary of Digestion in Man *(contd.)*

Region of the Digestive System	Digestion Of Food	
Small Intestine (*contd.*)	Absorption of digested food Assimilation	Absorption and Assimilation Villi absorb the food in its simplest forms; simple sugars, amino acids, water–soluble vitamins and salts into the blood stream, fatty acids and fat-soluble vitamins into the lymph vessels. Absorbed food is transported by blood. Absorbed food supplied to different parts of the body and used for various functions.
Large Intestine	Undigested food enters from small intestine.	***Egestion*** Water and salts are absorbed. More or less solid faeces is formed. Faeces leaves through anus.

Oxidation of food in higher organisms requires oxygen. The process releases carbon dioxide and water as by products. In several lower organisms, oxidation of food occurs in the absence of oxygen. Accordingly, respiration is of two types :

1. Aerobic Respiration : In aerobic respiration free oxygen of the air is used up to break down organic compound into carbon dioxide and water, releasing energy.

All the carbon in the organic compound is oxidised into carbon dioxide.

Glucose is the most common organic compound that is subjected to oxidation.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy (673 K Cals)

This type of respiration is found in all higher plants and animals.

2. Anaerobic Respiration : In anaerobic respiration, free oxygen is not necessary and organic compounds are incompletely oxidised into alcohol and carbon dioxide, releasing a little energy. It is otherwise known as intramolecular respiration and may be represented by the following equation.

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ + energy (56 K Cals)

This type of respiration is characteristic of lower organisms such as bacteria and yeast.

Activity 4.3 : To Demonstrate that Carbon Dioxide is Liberated during Aerobic Respiration.

Materials : A few germinating seeds, a retort, a beaker with potassium hydroxide solution, water, a stand with clamp.

Procedure : The germinating seeds are kept in the retort which is fixed to the stand as shown in Fig. 4.6. The free end of the retort is dipped in the beaker with KOH solution. The set–up is allowed to stand for a few hours.

Observation : KOH solutions starts rising in the retort.

Inference : Carbon dioxide is released during respiration.

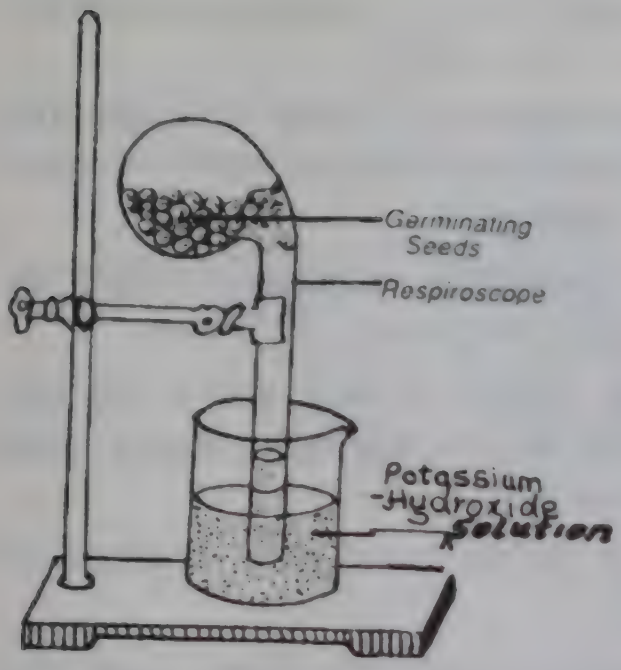

Fig. 4.6. Experiment to Show that Carbon–di–oxide is Released.

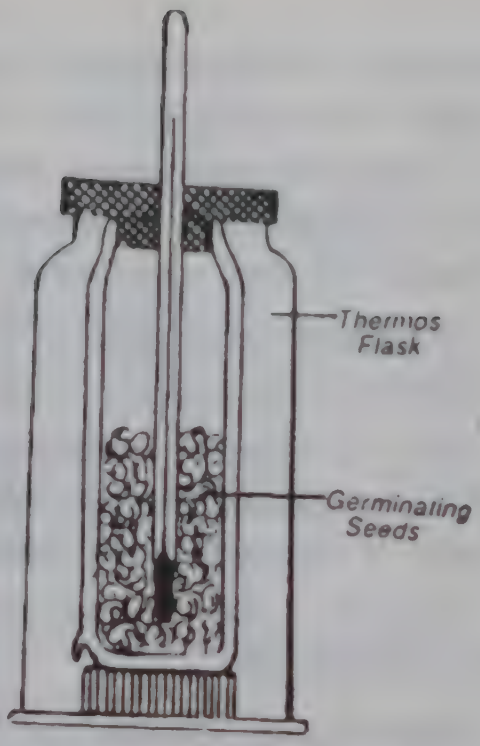

Fig. 4.7. Experiment to Show that Heat is Evolved.

Activity 4.4 : To Show that Heat is Evolved during Respiration

Materials : A thermos flask, a thermometer, a few germinating seeds.

Procedure : A few germinating seeds are taken in a thermos flask which is closed with a rubber cork having one hole. A thermometer is introduced into it, the bulb of the thermometer touching the seeds. Temperature is recorded at the start of the experiment and after a few hours.

Observation : A rise in temperature is recorded by the thermometer.

Inference : Heat is evolved during respiration.

Respiration in Animals

Animals largely exhibit aerobic respiration. Therefore, the body cells require oxygen for respiration. At the same time, the byproduct of respiration, carbon dioxide, must be eliminated from the cells. Thus, if a cell has to respire, it must not only be supplied with food, but also with

oxygen. It must also get rid of carbon dioxide. This exchange between oxygen and carbon dioxide occurs in two stages :

1. External respiration which involves the intake of oxygen from the surrounding liquid or gaseous medium and the elimination of carbon dioxide into that surrounding medium.

2. Internal respiration which involves the exchange of oxygen and carbon dioxide between blood and body cells.

Fig. 4.8 shows the respiratory system of man. It is in the form of a long passage for air, leading into the respiratory organs called lungs. It consists of the following parts :

Nostrils – pair of openings at the tip of the nose, to inhale the atmospheric air.

Nasal Cavity – a spacious cavity into which the nostrils open. It lies above the buccal cavity separated by a palate. Its passage is lined by hairs and moist, ciliated mucous membrane (to remove dust and impurities from air), numerous blood vessels (to warm the air) and sensory cells (to detect and smell).

Pharynx (Throat) – a small tubular portion from the nasal cavity. It serves as a common passage for air and food. Air passes through pharynx on its way to glottis.

Glottis – an opening of pharynx leading into the trachea.

Epiglottis – a connective tissue flap that prevents food from entering the trachea.

Larynx (Voice Box) – a short tube marking the upper part of the trachea. It has vocal chords stretched across and responsible for the production of sound.

Trachea (Wind Pipe) – a long tube supported by C–shaped cartilagenous rings. Internally it is lined with cilia and mucous membrane.

Bronchi – the two branches of trachea, one to each lung.

Bronchioles–branches of the bronchi, which become narrower towards their ends.

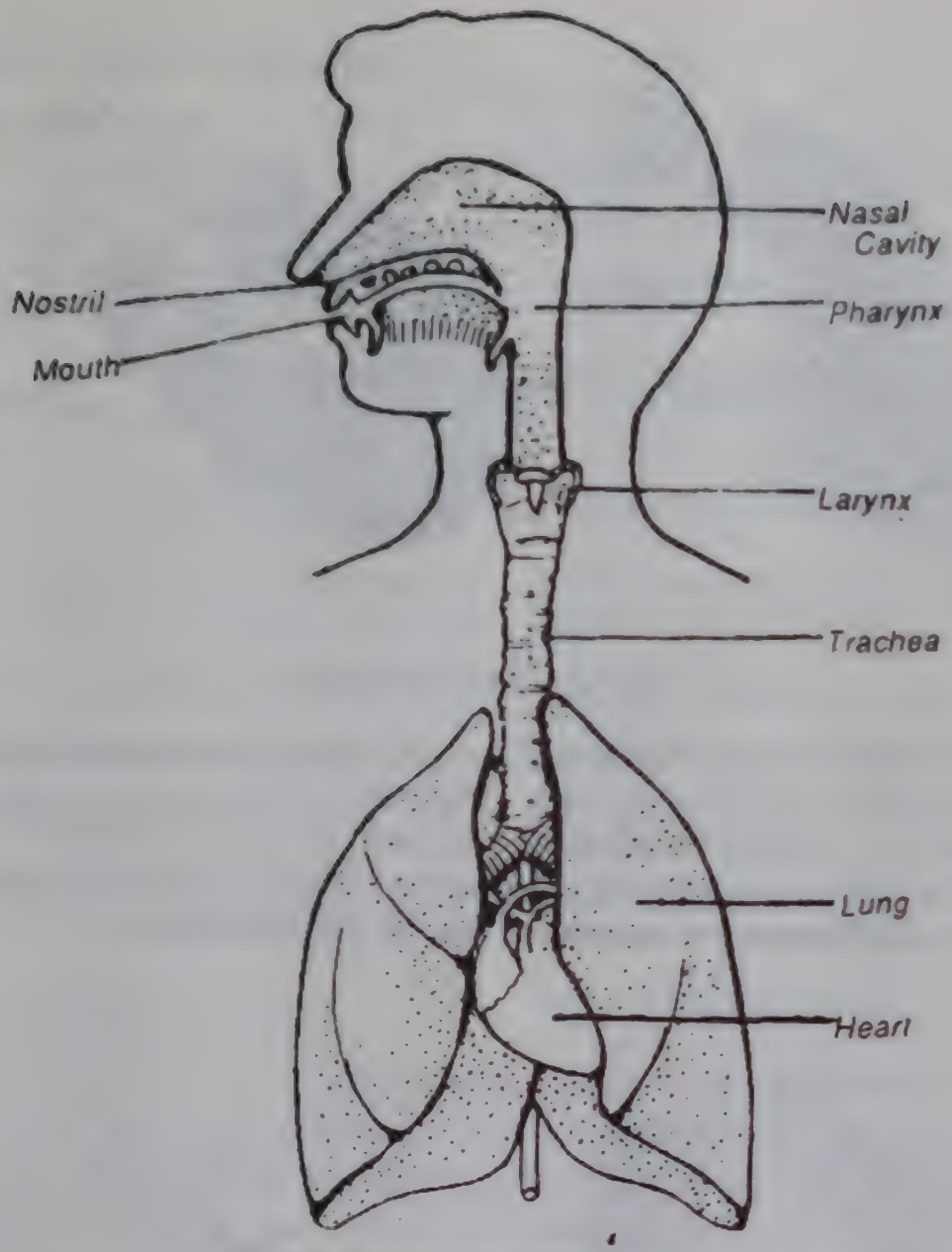

Fig. 4.8. Human Respiratory System

Alveoli–thin air sacs found at the tip of the bronchioles. Each alveolus has a wall of one cell thickness, surrounded by a network of capillaries. The alveoli represent the sites of gaseous exchange during external respiration.

Lungs–two sac like structures made up of spongy tissue. They are divided into lobes, each containing millions of alveoli. The lungs are surrounded by a two–layered **pleural membrane** which secretes a fluid to keep the lungs moist.

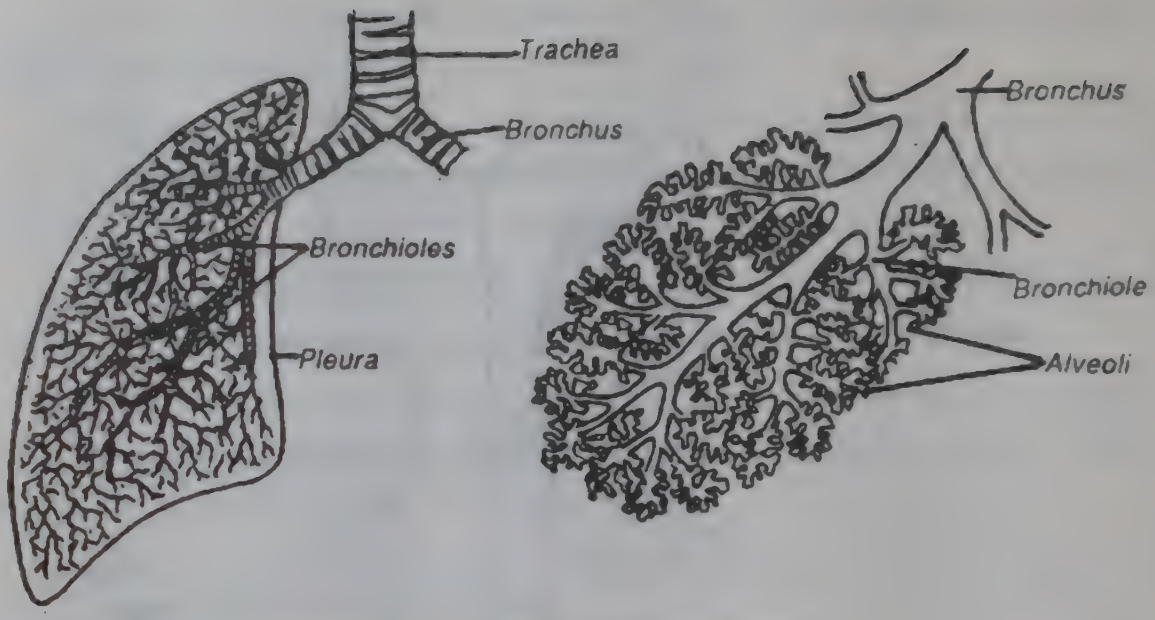

Fig. 4.9. Structure of the Lung

The lungs are situated in the thoracic cavity (chest cavity) enclosed by the sternum and the rib cage. Attached to the ribs are muscles, both on the outer surface (external intercostal muscles) and the inner surface (internal intercostal muscles). Below the lungs is a muscular membrane called **diaphragm** that separates **thorax** and **abdomen.**

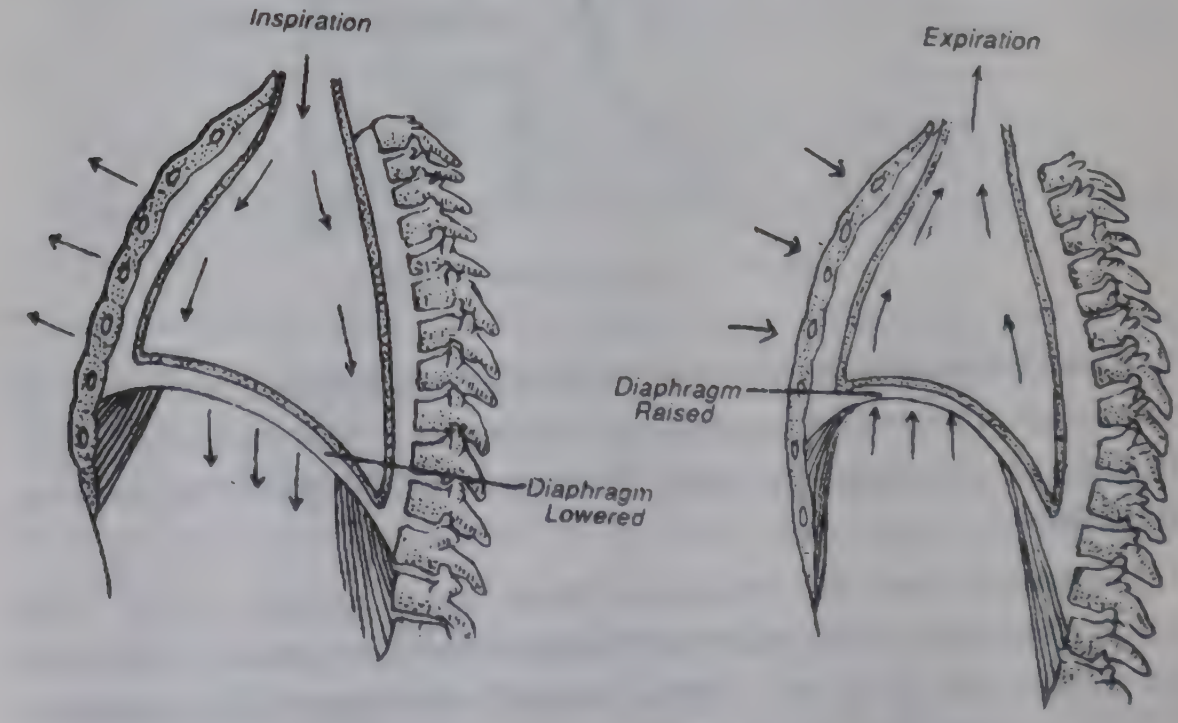

Fig. 4.10. Mechanism of Breathing

Mechanism of Breathing

The mechanism of breathing involves two movements in the respiratory system called breathing movements or ventilation. The two breathing movements are **inspiration** and **expiration.**

The changes that take place during breathing are listed in Table 4.2

Table 4.2. Changes during Breathing

	Inspiration (breathing in)	Expiration (breathing out)
1.	External intercostal muscles contract and internal intercostal muscles relax	External intercostal muscles relax and internal intercostal muscles contract.
2.	Ribs are raised upwards and outwards	Ribs move downwards and inwards.
3.	Abdominal muscles contract	Abdominal muscles relax.
4.	Diaphragm is lowered	Diaphragm is raised.
5.	Space in the thoracic cavity increases and pressure decreases	Space in the thoracic cavity decreases and pressure increases.
6.	Air is drawn into the lungs	Air is forced out of the lungs.

Gaseous exchange takes place in the alveoli immediately following inspiration. The blood capillaries and the alveoli and in close contact with each other. Hence, gaseous exchange takes place by diffusion. Oxygen dissolves in the fluid lining the alveolar wall and then diffuses through the capillary wall into the blood. In the blood, oxygen combines with the pigment haemoglobin and is transported to all the tissues of the body. At the same time, carbon dioxide diffuses in the opposite direction, through the capillary wall from blood, into the alveolar cavity.

4.4 Transport of Materials

In small organisms or in organisms where the body tissues have cells arranged near the surface, the nutrients and oxygen that are needed for maintenance and growth, can reach the individual cells by diffusion. In higher organisms, in order to obtain the advantages of larger body size, it has become necessary for them to evolve a

mechanism by which the nutrients can be supplied to each and every cell of the body.

Transport in Plants

Primitive plants like algae and liverworts transfer substances from cell to cell by diffusion. Ferns, conifers and flowering plants have specialised conducting tissues through which water and solutes are distributed to their different parts. There are two types of conducting tissues: Xylem which transports water and mineral salt from the roots to the shoot system; and **Phloem** which transports organic substances such as food. The movement of water and mineral salts is known as inorganic **translocation** or **ascent of sap**, the movement of food is known as **organic translocation.**

Activity 4.5 : To Show that Xylem is Involved in Inorganic Translocation.

Materials : Balsam plant, 1% eosin solution, beaker.

Procedure : A rooted balsam plant is placed in a beaker containing 1% eosin solution for a few hours.

Observation : Coloured streaks of water can be seen through the semitransparent stem. Thin sections of stem show the presence of coloured solution only in xylem.

Inference : Xylem is the path of inorganic translocation.

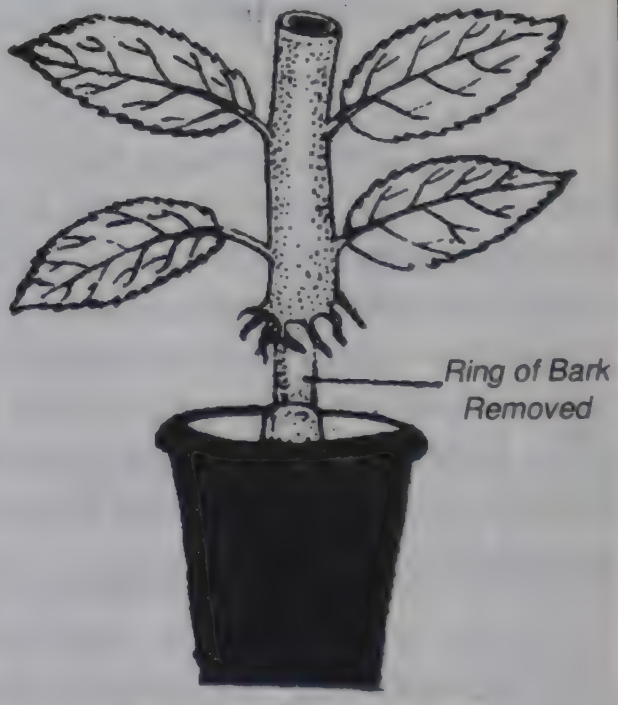

Fig. 4.11. Ringing Experiment

Activity 4.6 : To show that phloem is the path organic translocation (Ringing Experiment)

Materials : A potted plant, blade.

Procedure : A ring–like incision is made in the stem from which all the tissues, including phloem, are removed. The plant is kept under observation for a few days during which period, it is regularly watered.

Observation : A swelling appears in the region just above the incision.

Inference : Food does not get translocated in the absence of phloem.

Transport In Animals

Very small animals like **Amoeba or Paramecium** have a very large surface area that is exposed to their surroundings, compared to their body volume. Distribution of digested food and respiratory gases can easily take place by diffusion. Similary, in lower multicellular animals also, diffusion is sufficient to transport the substances. As animals evolved into larger and more complex forms, the number of cells in the body increased and diffusion was no more adequate. As a result, a new system developed which could transport substances to and from the interior and exterior of the body. The system which takes up this function is called **transport system or circulatory system**.

The circulatory system has the following essential components.

1. A fluid which can circulate throughout the body, called **blood.**
2. A system of tubes in which blood flows and reaches different parts of the body, called **blood vessels**.
3. A muscular organ which can pump blood in the blood vessels, called **heart**.

Blood

Blood is a fluid connective tissue. It contains a fluid matrix called **plasma** in which three types of cells are present.

The characteristics and functions of the components of human blood are summarised in Table 4.3.

Table 4.3 Components of Blood : Characteristics and Functions

Component	Properties	Function
Plasma	Consists of water(90%) Proteins	Some fibrinogen, proth–rombin involved in clotting; others are antibodies.
	Hormones	Transported from secreting glands to target cells.
	Nutrients–glucose, amino acids, fatty acids, glycerol and vitamins	Transporoted to all the living cells.
	Inorganic ions–calcium, sodium, potassium, bicarbonate and chloride	Maintenance of electrolyte balance.
	Urea	Metabolic waste transported from liver to kidney for removal.
Red Blood Corpuscles (Erythrocytes)	Biconcave discs, containing haemoglobin; no nucleus formed in bone marrow	Transport of respiratory gases—oxygen and carbon-di-oxide.
White Blood Corpuscles (Leucocytes)	Phagocytes with lobed nucleus formed in bone marrow	Engulf bacteria by phagocytosis. Defend the body against diseases.
	Lymphocytes with unlobed nucleus, formed in lymph nodes	Produce anti-bodies.
Platelets	Cell fragments formed in bone marrow	Release substances necessary for clotting. Stick to the surface of damaged vessels.

Blood Vessels

There are three types of blood vessels, namely, arteries, veins and capillaries. Their characteristics are listed in Table 4.4.

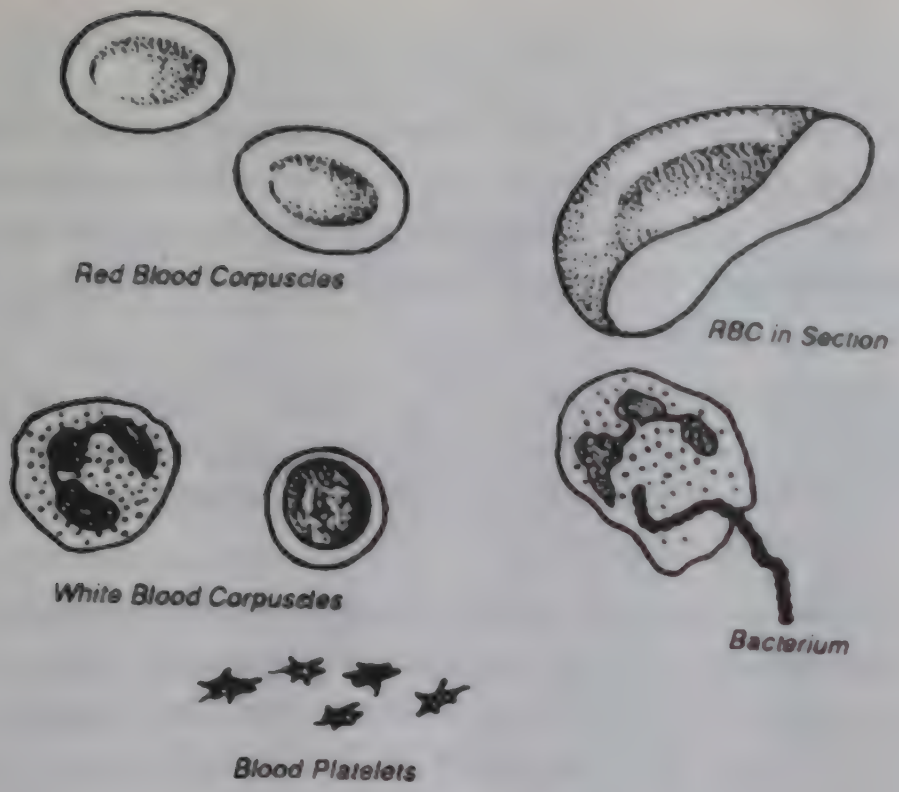

Fig. 4.12. Blood Cells

Table 4.4 Characteristics of Blood Vessels

	Artery	Capillary	Vein
Wall	Thick-contains a thick layer of smoothfibre	Only one–cell thick	A thin layer of smooth muscles muscle and elastic
Lumen	Cylindrical,narrow without valves	Much narrow, about the size of an RBC Valves absent	Wider than artery. Valves present to prevent back flow.
Blood Flow	Faster, underpressure, due to heart muscle contraction	Slow and smooth gradient of blood pressure	Slow and smooth by skeletal muscle found surrounding the veins.
Function	Carrying blood away from the heart	Exchange of materials between blood and tissue cells	Returning blood to the heart.

Heart

The human heart is a small muscular pumping organ, about the size of the fist. It is situated in the thoracic cavity in the space between the two lungs. It is surrounded by a transparent double membrane called **pericardium.** The heart is protected by the sternum and the rib cage.

The heart has four chambers : two upper chambers called **atria** or **auricles** and two lower chambers called **ventricles**. The auricles are commonly known as receiving chambers while the ventricles are known as pumping chambers.

The right side of the heart receives and pumps deoxygenated blood, whereas the left side receives and pumps oxygenated blood. The two sides are separated by a muscular septum. The flow of deoxygenated blood from right auricle to right ventricle is maintained by a **tricuspid valve**. Similarly, the flow of oxygenated blood from left auricle to left ventricle is maintained by a **bicuspid valve**. The right ventricle pumps the deoxygenated blood into the **pulmonary artery** which takes blood

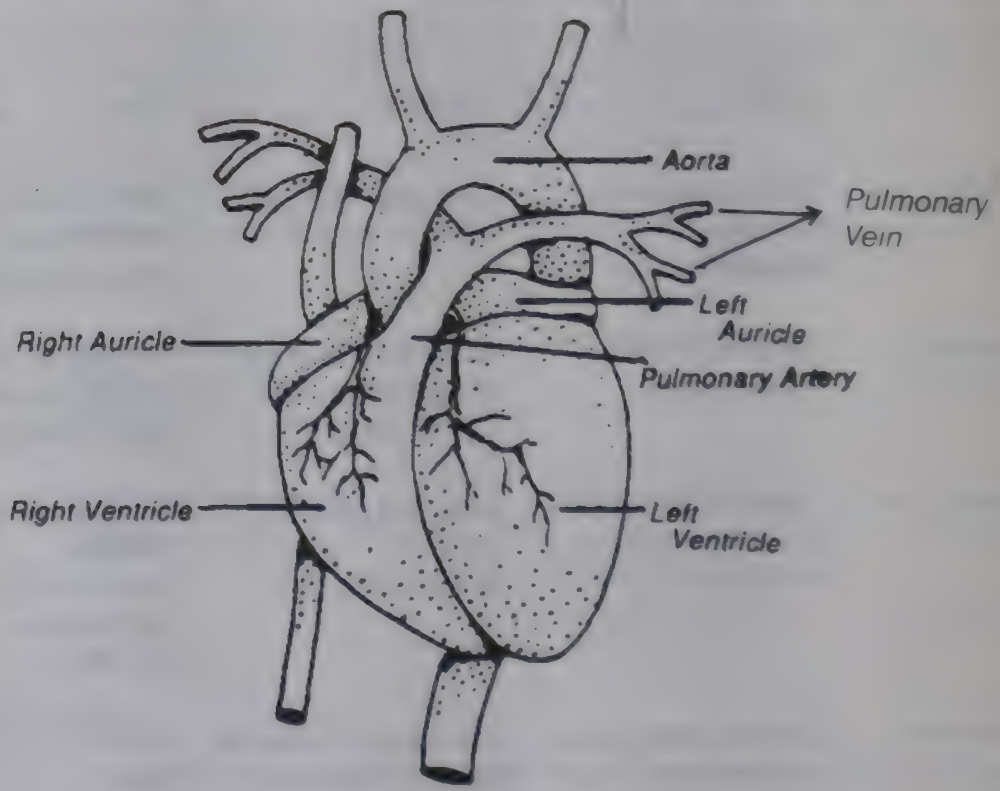

Fig. 4.13. Human Heart

to the lungs for purification. The left ventricle pumps the oxygenated blood into the aorta which carries blood to different parts of the body through its branches called arteries.

The heart is composed of a special type of muscle called **cardiac muscle**. It exhibits a highly rhythmic contraction and relaxation that creates the pressure required to maintain the flow of blood throughout the body. The cycle of contraction and relaxation of the heart is known as **cardiac cycle.**

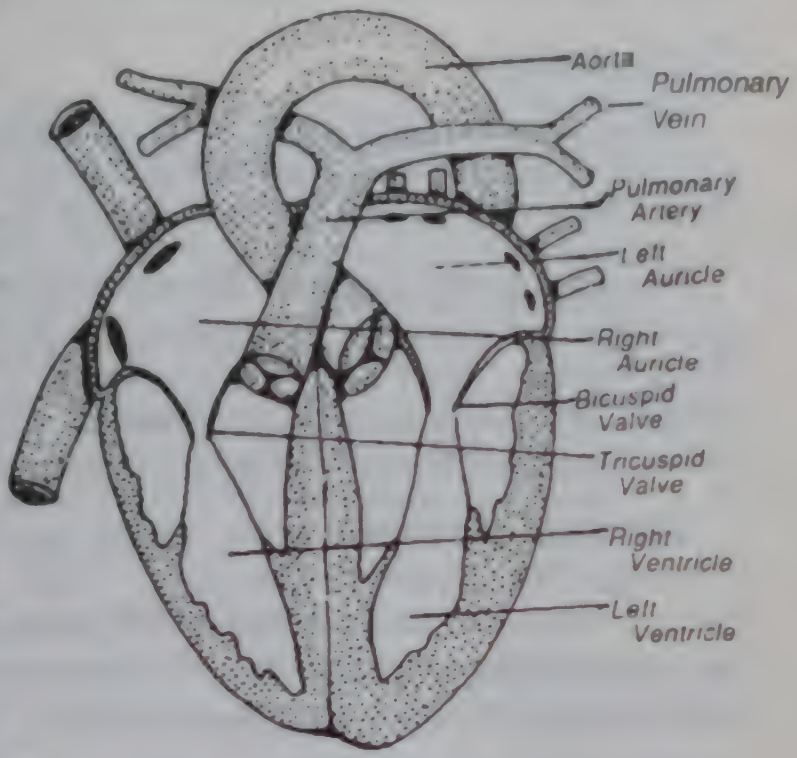

Fig. 4.14. Human Heart (in Vertical Section)

Rhythmic lub lub sound is produced

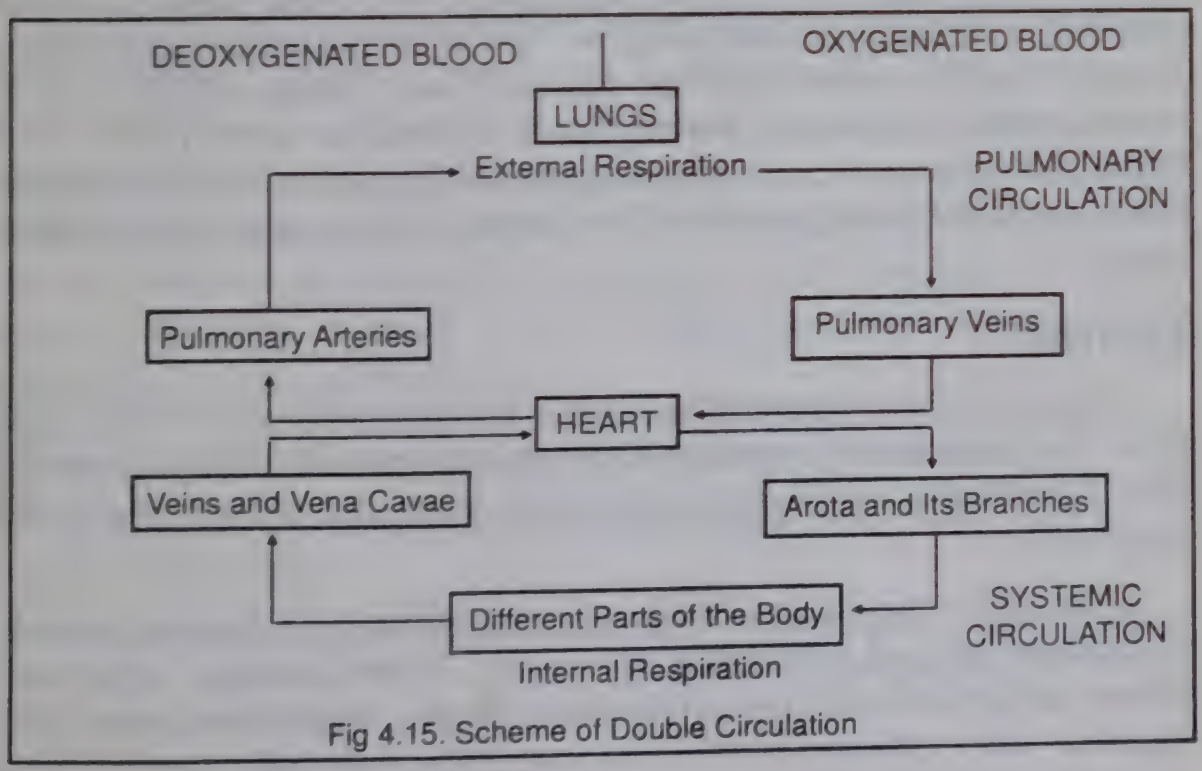

Fig 4.15. Scheme of Double Circulation

during the contraction and relaxation of heart chambers. This is called heart beat. In an adult man the rate is about 70 beats per minute.

Circulation

Blood blows through the heart twice to complete one circulation in the body, once in the **pulmonary circulation** and once in the **systemic circulation.** Hence the type of circulation is described as **double circulation.**

Pulmonary circulation is the course taken by blood between heart and lungs. The deoxygenated blood from heart enters the lungs through the pulmonary artery and its branches. In the lungs carbon dioxide is released and oxygen absorbed **(external respiration).** The oxygenated blood is returned to the heart through the pulmonary veins.

Systemic circulation is the course taken by blood between heart and lungs. The oxygenated blood from heart reaches the different parts through aorta and its branches. After gaseous exchange in the tissue cell **(internal respiration),** the deoxygenated blood is returned to the heart through the veins and the vena cava.

Double circulation is an effecient transport mechanism. It keeps the oxygenated blood separate from the deoxygenated blood. (The flow of Blood, in the arteries exerts pressure on their elastic walls). The muscular septum in the heart ensures this separation. The blood pressure in the systemic circulation is always higher than in the pulmonary circulation. The left ventricle with its thicker muscular wall pumps blood under a higher pressure to deliver the oxygenated blood to all the parts of the body. The right ventricle which is slightly less muscular pumps blood to the lungs under lesser pressure. This avoids any damage to the delicate lungs.

Lymph

It is a colourless fluid that is found in the spaces between the tissue cells. Its composition is almost similar to the plasma of blood, except that it contains much less proteins and does not contain red blood corpuscles.

Lymph from tissue spaces flows in vessels called lymphatic vessels or lacteals, almost resembling the veins. These vessels, which are closely associated with **lymph nodes** that have defensive function join together from different parts of the form they lymphatic ducts. These

ducts, in turn, empty lymph into the venous system just before it enters the heart. The flow of lymph is relatively slow.

4.5 Excretion

We have so far discussed how plants and animals acquire nutrients and oxygen distribute them to their cells. The metabolic activities taking place in the cells result in the formation of some byproducts. These waste products can become toxic if allowed to accumulate in high concentration. Hence, the **waste products** are to be eliminated from the body as and when they are formed. This removal of metabolic waste products, is known as **excretion**. Many of these waste products are usually soluble in water. Therefore, excretion is closely linked with another problem–maintenance of water balance or **osmoregulation.**

Excretion and Osmoregulation in plants

In higher plants, the waste products are mostly in the form of tannins or toxic nitrogenous alkaloids and anthocyanins which provide colour to the petals and fruits. Plants have no special excretory organs. These substances are get–rid–of by plant when it sheds its bark, leaves and petals.

Plants also face the problem of losing water from the body through **transpiration.** Water is lost in the form of vapour from the aerial parts of a plant, particularly the leaves. To a plant growing in a well–watered soil, this presents no problem as the water transpired in replaces by the root system from the soil. However, in desert plants we see various modifications to conserve water, because in cases where availability of water is much less. Xerophytes are excellent examples for this phenomenon.

Activity 4.7 : To Show Loss of Water from a Plant Body

Materials : A potted plant, plastic sheet, glass plate, bell-jar, vaseline or grease.

Procedure : A potted plant is placed on a glass plate. Soil portion of the pot is covered by the plastic sheet so that the well–watered soil is not directly exposed to sunlight.

A bell–jar, with vaseline at the rim, is inverted over the plant. The set–up is observed after one hour.

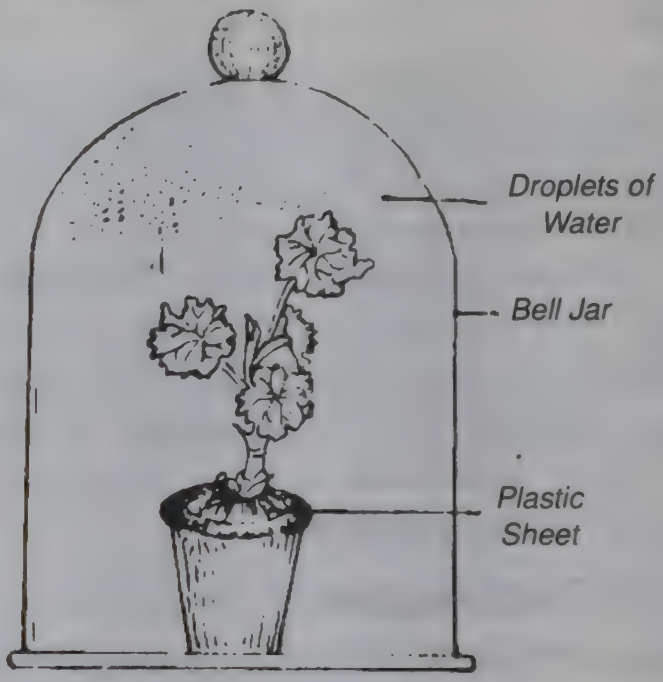

Fig. 4.16. Experiment to Show Transpiration

Observation : Droplets of water are seen condensed on the inner surface of the bell-jar.

Inference : The source of water is transpiration from the leaves.

Excretion in Animals

Animals are much more active than plants, particularly as they are capable of moving around. Therefore, animals require more energy and produce a great deal of waste materials. Moreover, animal cells can store very little proteins and there are no special storage organs for proteins. As a result, the excess of amino acids resulting from the breakdown of proteins, are split up by a process called **deamination.** It results in the formation of certain nitrogen containing waste products such as ammonia, urea and uric acid. Some of these waste products can become toxic beyond a particular concentration and hence require immediate elimination. The system, which is involved in this funcion is called **excretory system.**

Fig. 4.17 (A) shows the excretory system of man. It consists of a pair of **kidneys**, a pair of **ureters**, a **urinary bladder** and a **urethra.**

The kidneys are dark, red–coloured, bean–shaped structures situated in the abdominal cavity, one on either side of the backbone. Arising from the inner concave surface of each kidney is a duct called kidney duct or ureter which opens into the urinary bladder situated in the lower part of the abdomen. The urinary bladder opens out through the urethra.

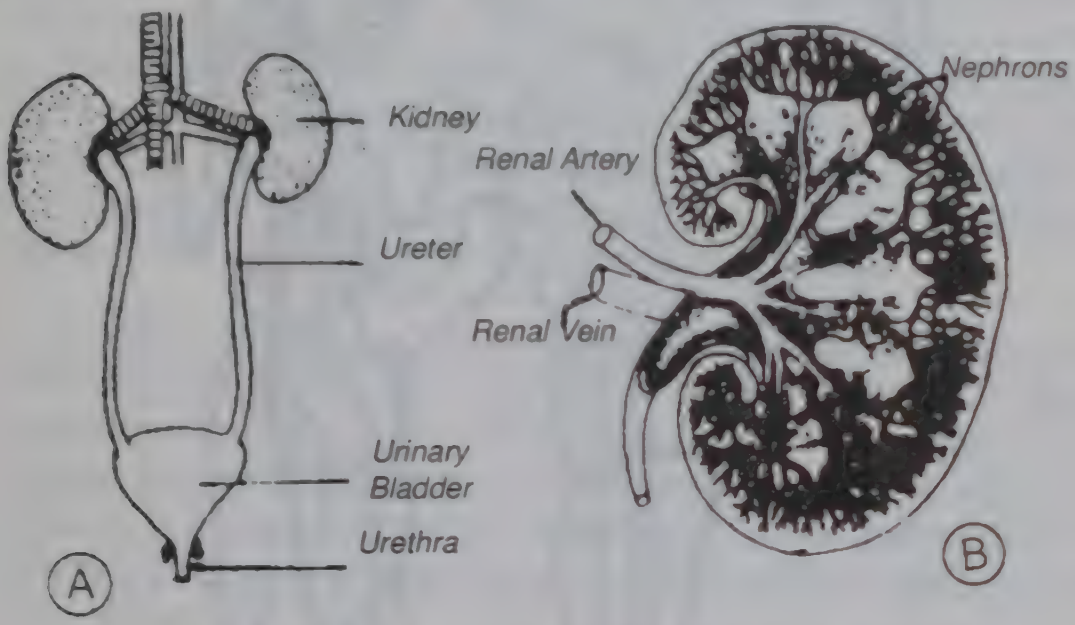

Fig. 4.17 (A) Human Excretory System; (B) Kidney (in Section)

The kidney shows two distinct parts, namely, an outer **cortex** and the inner **medulla**. The medulla opens into the ureter through the renal pelvis. The kidneys enclose a large number of minute, microscopic units called **nephrons**. Each nephron begins in the cortex as a thin–walled, cup–shaped structure called **Bowman's capsule** which encloses a network of capillaries called **glomerulus**. The Bowman's capsule is continued as the renal tubule. It shows three parts, namely, an anterior **proximal convoluted tubule**, a middle U-shaped **Henle's loop** and a posterior **distal convoluted tubule**.

The blood reaching the glomerulus contains nitrogenous wastes in the form of urea formed in the liver. It enters the nephrons with a high pressure, and as a result, blood is filtered in the **glomerulus**. This process

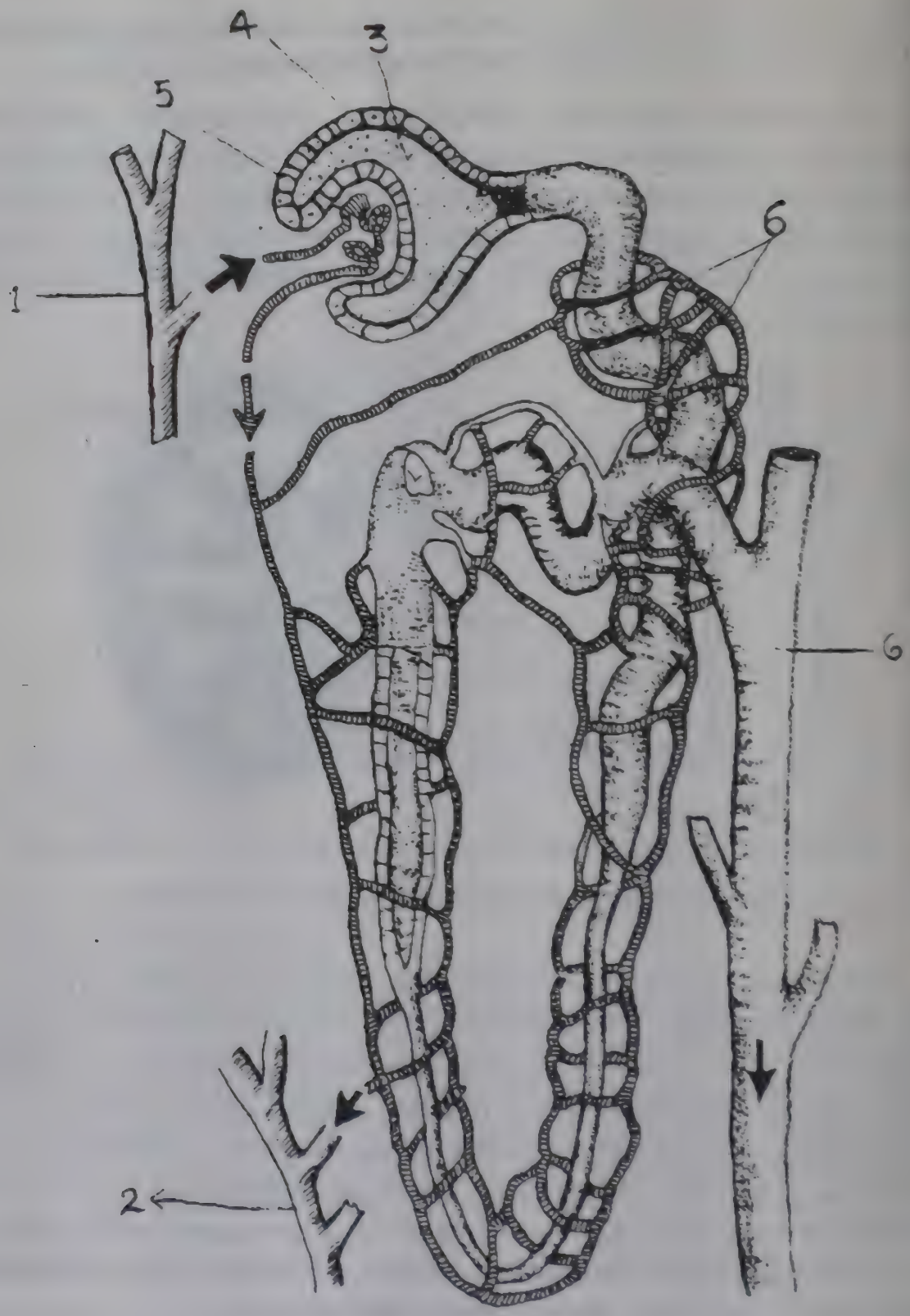

Fig. 4.18 Uriniferous Tublule and Blood Vessels
1. Branches of on artery 2. Branch of a Vein 3. Bowman's Capsule 4. Epithelial cells
5. Capillaries 6. Collecting tubule

is known as **glomerular filtration.** The larger molecules, like proteins and blood cells, do not get filtered. The filtrate which contains glucose and other digested food components, salts and urea, along with a large quantity of water, starts trickling down through the renal tubule.

As the filtrate passes through the convoluted tubules, almost all the substances like glucose, amino acids, fatty acids and glycerol, a major part of the salts and water are reabsorbed into the surrounding capillaries. This process is known as **selective reabsorption**. The filtrate now contains only water and urea. As the filtrate reaches the terminal part of the nephron, a few other metabolic wastes, particularly some ammonium salts, are added. This process is known as **tubular secretion.** The filtrate, with urea and other nitrogenous wastes and excess of salts, is taken to the urinary bladder through the ureter as **urine**. In the urinary bladder it is temporoarily stored.

In addition to their role in the removal of metabolic waste products, the kidneys also maintain a constant water balance in the body. When the plasma is dilute with water, the kidneys excrete more water. When the plasma becomes concentrated, the kidneys absorb more water into the blood and thereby the normal composition of the plasma is restored. Similarly, the salt and sugar content of the plasma is also regulated by the kidneys.

Skin as an Excretory Organ

The skin of man also functions as an excretory organ due to the presence of sweat glands. Each sweat gland is a long coiled tube which opens on the surface of the skin through a minute sweat pore. The secretion of the sweat gland is called **sweat**. It is a salty solution which helps to cool the body by evaporation and to maintain the body temperature. It also contains a small quantity of urea.

4.6 Reproduction

Reproduction means production of young ones which resemble the adult. Though reproduction is not necessary for the well–being of an organism, it is absolutely necessary for the continuation of the species.

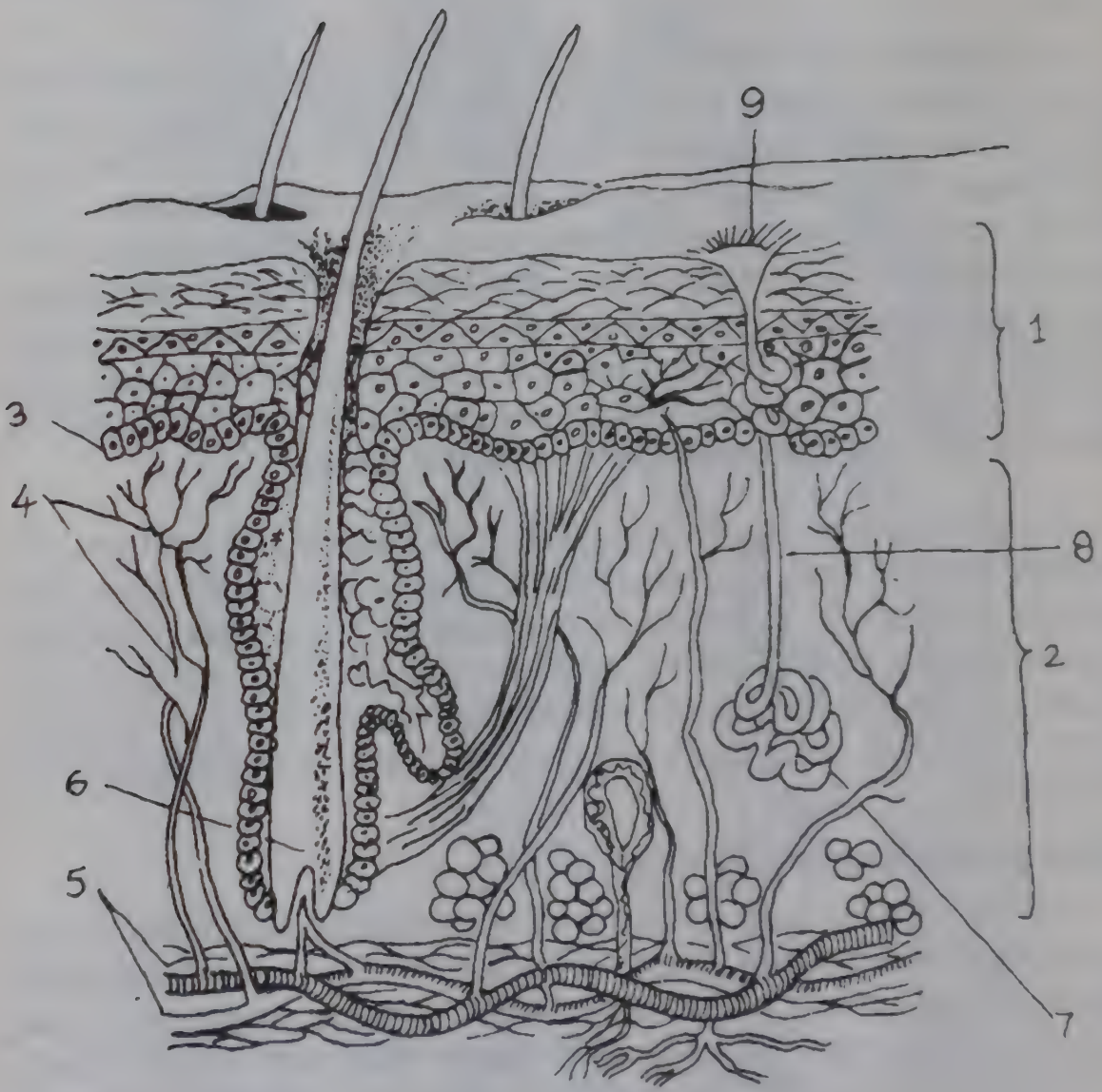

Fig. 4.19 The skin

1. Epidermis
2. Dermis
3. Germinating Layer
4. Nerves
5. Blood Vessels
6. Hair Follicle
7. Sweat gland
8. Sweat duct
9. Sweat Pore

Reproduction is basically a process in which a mature organism can produce its own kind. It is mainly of two types: 1. asexual reproduction; and 2.sexual reproduction.

1. Asexual Reproduction: It is a type of reproduction which does not involve the fusion of reproductive cells or gametes. New individuals develop from spores or by budding or from bits of the parent organism. Asexual reproduction is very common among bacteria, yeasts, protozoans and other primitive animals and some plants. The following are some of the most common types of asexual reproduction.

(i) Fission : It is seen in single-celled organisms. Bacteria and protozoans usually reproduce by fission. Here the parent cell splits into two or more bits. Each bit grows into an adult organism. When only two bits are formed by the parent cell, the process is called **binary fission,** and when a large number of bits are formed, the process is called **multiple fission.**

Fig.4.20. Binary Fission in Amoeba

(ii) Budding : Budding of new cells from old ones is a common method of reproduction seen in some bacteria and yeast. The bud which grows as a projection from the parent cell eventually gets separated and develops into a new organism.

Budding is seen in some primitive multicellular animals like Hydra. Here, the bud arises as a projection from the parent body, towards the base It develops mouth, tentacles and other associated structures and then gets pinched off from the body of the parent.

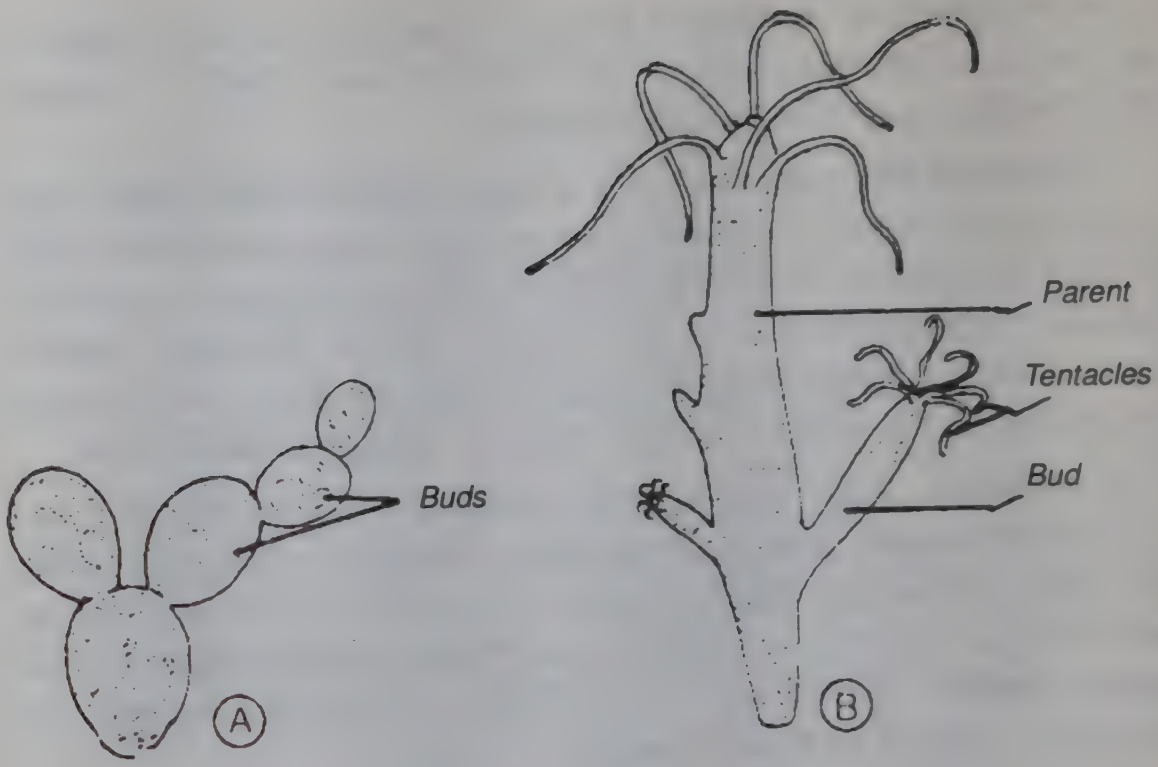

Fig. 4.21. Budding in (A) Yeast; (B) Hydra

(iii) Fragmentation : It is seen in algae and flatworms. In some filamentous algae, such as *Spirogyra,* the filaments break up into two or more bits called **fragments**. Each fragment grows into a new filament.

In flatworms like **Planaria** the adult body pinches off into two to many fragments. Each fragment develops the necessary structures and becomes an adult flatworm.

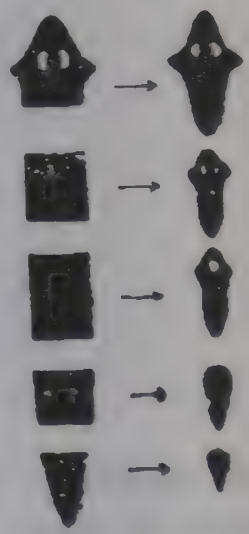

Fig. 4.22
Fragmentation in
Planaria

(iv) Spore Formation : A large number of fungi and sea–weeds such as mosses and ferns reproduce by producing structures called **spores.** The spores are produced in structures called **sporangia**. Under favourable conditions the spores give rise to new individuals.

(v) Vegetative Propagation : Many flowering plants possess the ability to produce new individuals from a part of the body which is

not associated with reproductive organs. This is known as **vegetative reproduction.**

Any vegetative part of the plant body may be involved in producing new individuals. In the plant, *Bryophyllum*, adventitious roots and buds develop in the notches along the margin of the leaf. Each one of them develops into a new plant. Some plants like hemp develop aerial tubers called bulbil in the axils of lateral leaves. When they are mature they drop off and give rise to new plants.

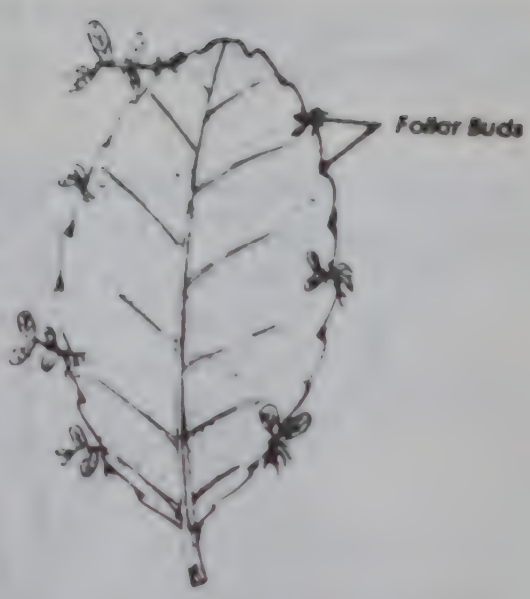

Fig. 4.23. Vegetative Reproductionin Bryophyllum

Banana, pineapple and many other plants produce **suckers** or **offsets**. These are short horizontal branches given off by a stem at or just below the ground level. The terminal bud of these suckers is able to give rise to a new plant.

Plants like sweet potato have a creeping stem called **runner** which generally produces roots at the nodal regions. These roots can give rise to new plants.

Underground shoots like tubers(potato), rhizomes(ginger) and bulbs(onion) which are primarily food storage organs, can also function as organs of vegetative reproduction.

The advantages of vegetative reproduction are being widely used by man for his benefits in fields like farming (agriculture) and gardening (horticulture). Some common techniques like cutting, layering, budding and grafting are examples of methods employed for propagating useful plants.

2. Sexual Reproduction : It is a type of reproduction which involves fusion of two reproductive cells called **gametes** to form a single cell called **zygote** which develops into a new individual. The two gametes

which undergo fusion may be produced by the same parent or by two different parents.

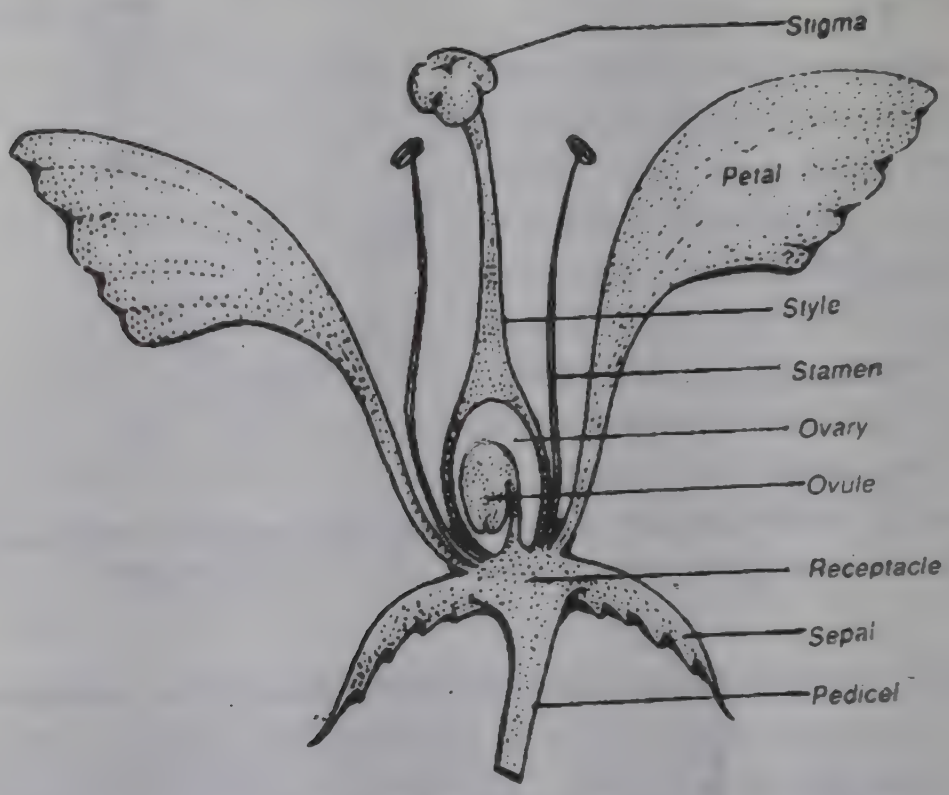

Fig. 4.24 Parts of a Flower

Sexual Reproduction in Plants

In higher plants like pea, bean and mango sexual reproduction is carried out by a part of the shoot system modified for this purpose. It is called **flower.** It is the reproductive organ of a plant.

A typical flower has a stalk called **pedicel**, the tip of which is swollen to form a **receptacle**. The parts of the flower are attached to the receptacle in whorls. There are four parts in a flower.

1. Calyx : It consists of small, green–coloured, leaf–like structures called sepals.

2. Corolla : It consists of large, usually brightly–coloured structures called **petals**.

3. Androecium : It consists of male reproductive structures called **stamens**. They produce pollen grains which contain the male reproductive cells or gametes.

4. Gynoecium : It consists of female reproductive structures called **carpels** or **pistils**. The basal, swollen portion of the carpel is called **ovary**. It encloses one to many ovules in which are present the female gametes. The carpel also has a long **style** and a terminal **stigma**.

Activity 4.8 : Select a typical flower such as Hibiscus. Examine the different parts of the flower and their arrangement.

Pollination : It is the process which involves the transfer of pollen grains from the stamens to the carpels. If the pollen grains fall on the stigma of the same flower, the process is known as **self pollination**. If the pollen grains fall on the stigma of another flower of the same kind, the process is known as **cross pollination**. Cross pollination is brought about with the help of agents like wind, water, insects and birds.

Fertilization : It is a process which follows pollination. Each pollen grain develops a long hollow outgrowth called **pollen tube** which finally reaches the ovule through the style. The male nucleus in the pollen tube fuses with the female nucleus in the embryo sac to form the zygote.

Following fertilization, a few changes occur in the flower. The zygote divides into many cells to form the embryo. The ovule becomes the seed while the ovary enclosing the ovule becomes the fruit. The sepals, petals and stamens eventually drop off from the flower.

Structure of a Seed : The seed is a fertilized ovule containing the embryo and reserve food. The embryo has one or two seed leaves, called

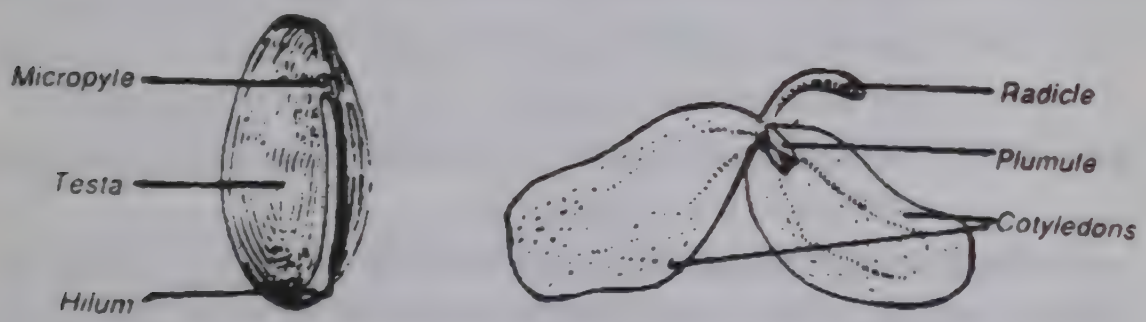

Fig. 4.25. Structure of a Bean Seed

Cotyledons. A seed with a single cotyledon is described as **monocotyledonous** (e.g. maize) and that with two cotyledons is described as **dicotyledonous** (e.g. bean).

Let us take the bean seed as an example and study its parts. The seed is just over one cm. long and roughly kidney–shaped. On one side of the seed is a scar called **hilum**. The seed has two protective coats,

> **Activity 4.9** : Soak a few bean seeds in water for a few hours. Examine the soaked seeds. Remove the seed coat and see the various parts you have just studied.

an outer **testa** and an inner **tegmen**. The testa surrounding the hilum is darker. Just above the hilum is a minute pore called **micropyle**.

When the seed coat is peeled off, the seed shows the embryo consisting of a **radicle** and a **plumule**. Radicle is part of the embryo which grows into the root system while plumule grows into the shoot system.

Germination of the Seed : Germination requires three conditions, water, oxygen and ideal temperature. During germination the following changes take place.

* Water enters the seed through micropyle. The testa becomes soft and the seed swells.
* The radicle emerges out through the seed coat.
* The hypocotyl lying just above the radicle elongates. It forms a loop.
* The loop becomes erect and the cotyledons spread out.
* The plumule now elongates and the first leaves spread out.
* The plumule and radicle absorb nourishment from the cotyledons which gradually shrink and finally drop off.
* The first leaves start synthesizing food and a new plant emerges in the course of time.

In monocots the cotyledons remain below the soil during germination. This process is called **hypogeal** germination. In most dicots, the cotyledons emerge above the soil during germination. This type of germination is described as **epigeal**.

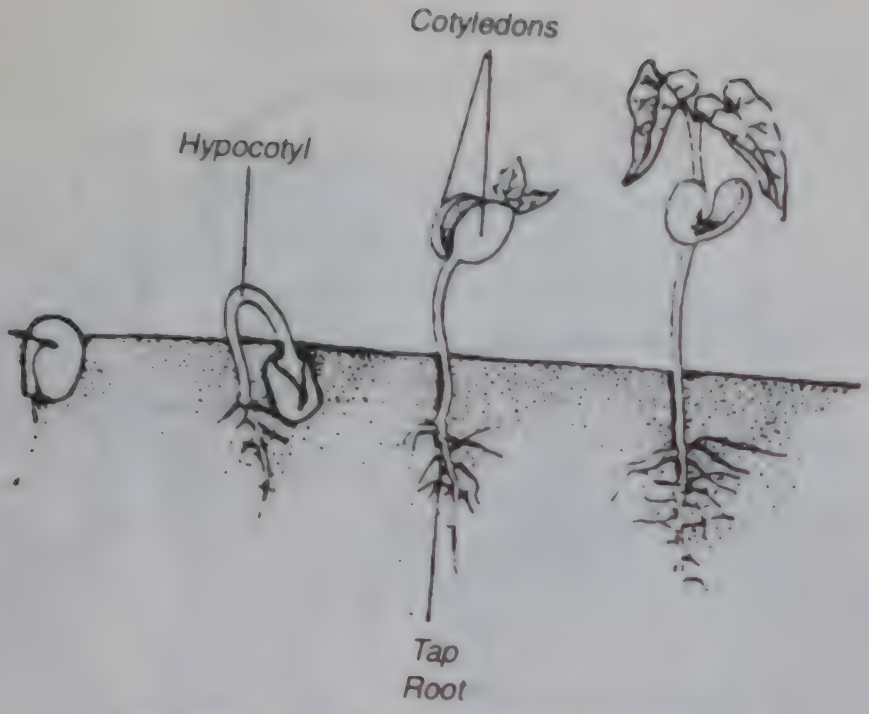

Fig. 4.26. Stages in the Germination of a Seed

Sexual Reproduction in Animals

Higher animals exhibit only sexual reproduction. It involves the production and fusion of haploid sex cells called gametes. The gametes are of two types : male gametes or spermatozoa and female gametes or **ova**. The gametes are produced in reproductive organs called **gonads**. The gonads and the structures associated with them form the reproductive system.

Fig. 4.27 shows the reproductive system of man. It has the following parts.

1. **Testes** : a pair of male gonads which produce the spermatozoa.

2. **Scrotal Sacs** : a pair of sacs enclosing the testes, one on each side.

3. **Epididymis** : a coiled duct arising from testis where the mature sperms are stored.

4. **Sperm Duct** : a duct from epididymis to transport the sperms.

5. **Urethra** : a common duct into which the sperm ducts of the two sides unite.

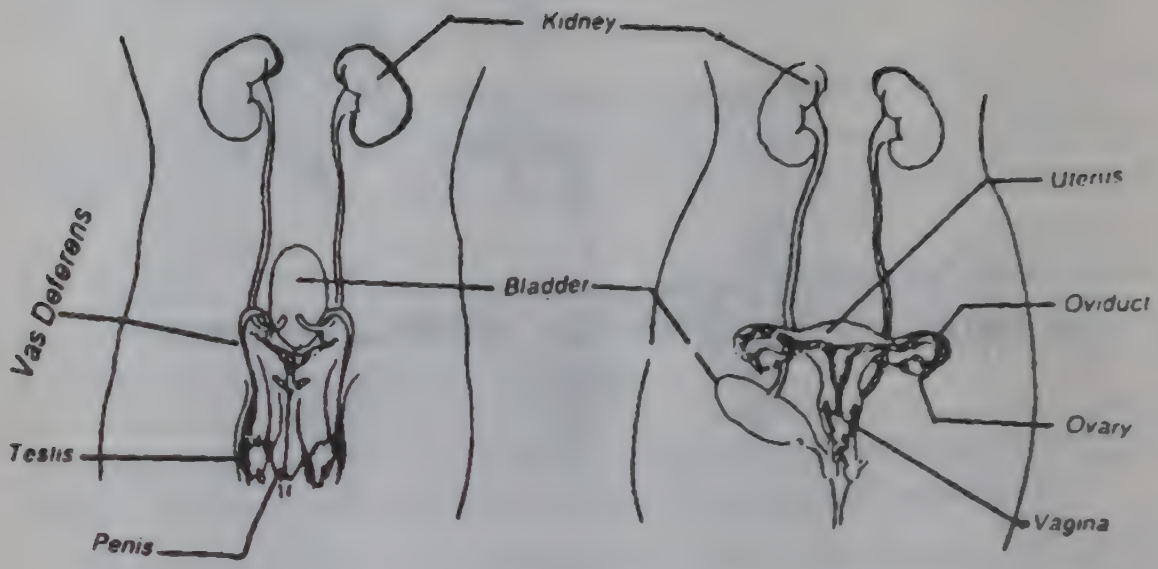

Fig. 4.27
Male Reproductive System

Fig. 4.28
Female Reproductive System

6. **Penis** : a muscular organ meant for transferring the sperms into the female reproductive system.

7. **Seminal Vesicles and Prostate Gland** : to produce a fluid that nourishes the sperms.

In mammals, in general, the testes are kept outside the body, in the scrotal sacs, because the body has a high constant temperature which is detrimental to sperms.

Fig. 4.28 shows the reproductive system of woman. It has the following parts.

1. **Ovaries** : a pair of female gonads which produce the ova.

2. **Oviducts** : a pair of ducts where fertilizaion takes place. The oviducts are also called **Fallopian ducts.**

3. **Uterus** : a large muscular sac into which the oviducts open. It is the region where the embryo attaches and undergoes development. It is also called **womb.**

4. **Vagina** : a short tube to receive the sperms during mating.

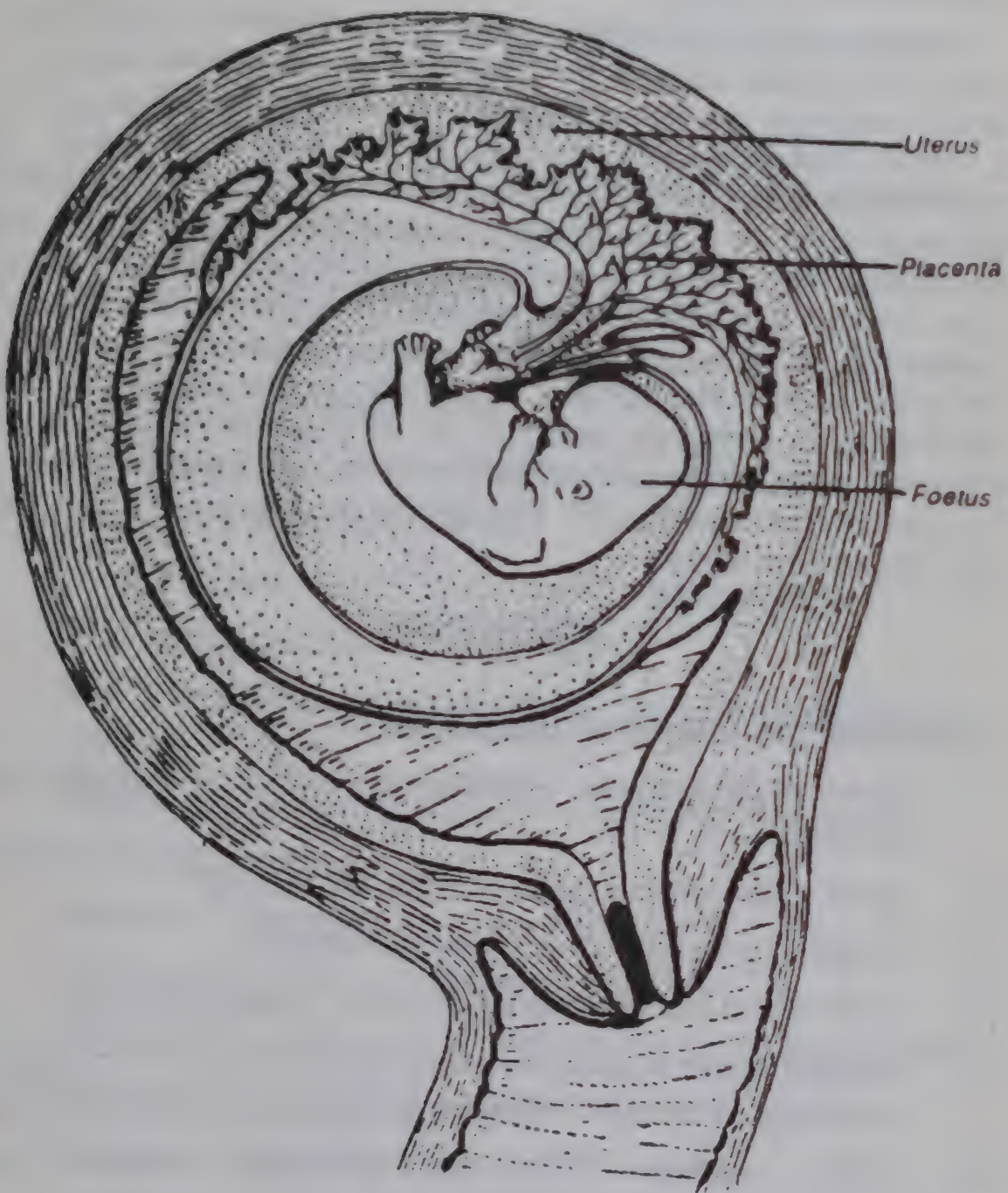

Fig. 4.27. Human Foetus in Uterus Showing the Placenta

Following mating, the sperms, released into the vagina swim upwards into the oviduct. If the ovum is available, fertilization occurs resulting in the formation of a **zygote.**

The zygote starts undergoing mitotic division to form a ball of cells. This is the earliest stage of the embryo. It moves towards the uterus where it becomes attached to a suitable region on the wall. This process is called **implantation.** In the uterus, the embryo completes its development. The period between fertilization and birth is called gestation period. In human beings it is about nine months. During this period the embryo derives its nourishment and oxygen from the mother's blood through a structure called placenta. The embryo also receives antibodies through the placenta. The metabolic wastes from the embryo are released into the mother's blood through the placenta. It also secretes some harmones necessary for development. Meanwhile the embryo is set to float in a sac of fluid with in the uterus and it is attached by a cord called umblical cord. Through the cord the embryo gets food and oxygen from mother.

EXERCISES

I. Answer the following questions.

1. Define photosynthesis. Describe the major steps involved in the process.
2. Draw a neat labelled diagram of the T.S. of a leaf.
3. Explain the steps involved in animal nutrition.
4. Draw a neat labelled diagram of human digestive system.
5. Prepare a table showing the fate of the food in the following regions of the alimentary canal : (i) Mouth (ii) Stomach (iii) Small intestine.
6. Define respiration. Name the major steps involved in the breakdown of glucose in cells.
7. Draw a neat labelled diagram of the human respiratory system.
8. What is breathing / Describe the mechanism of breathing.
9. What is inorganic translocation? What is its pathway?

10. Describe the components of human blood.
11. What is double circulation? What is its significance.
12. Describe the structure of human heart with the help of a neat labelled diagram.
13. What is excretion?
14. How does excretion in plants differ from excretion in animals?
15. Describe the excretory system of man.
16. Describe the process of urine formation in man.
17. What is fission? Explain the following giving examples;
    (i) Budding; (ii) Fragmentation.
18. What is vegetative propagation? Explain any two types.
19. Describe the structure of a flower.
20. Define the terms; (i) Pollination; and (ii) Fertilization.
21. Describe the structure of a bean seed.
22. Draw a neat labelled diagram of the human male reproductive system.
23. Describe the structure of human female reproductive system.

II. Name the following :

1. The pigment necessary for photosynthesis
2. The digestive secretion produced in the mouth
3. The part of the respiratory tube responsible for producing sound
4. The pigment responsible for transport of oxygen to cells
5. The process of loss of water from the plant body
6. The process of loss of water from the plant body in the vapour form
7. The process which involves maintenance of a water balance in the body
8. The microscopic structures in the kidneys
9. The spore producing structure in some plants

10. The most colourful part of a flower
11. The part of the female reproductive system where fertilization occurs
12. The organic connection through which the embryo derives nutrition from the mother

III. Mention the differences between :

1. Holophytic nutrition and Holozoic nutrition
2. Autotrophs and Heterotrophs
3. Light reaction and Dark reaction of photosynthesis
4. Absorption and assimilation
5. Egestion and Excretion
6. External respiration and Internal respiration
7. Pulmonary circulation and Systemic circulation
8. Blood and lymph
9. Excretion and Osmoregulation
10. Asexual and Sexual reproduction
11. Fission and Fragmentation
12. Plumule and Radicle

IV. Fill in the blanks :

1. The end product of photosynthesis is _____.
2. The rhythmic contractions in the wall of oesophagus are known as _____.
3. The enzyme which breaks down milk protein is_____.
4. The secretion that brings about emulsification of fats is_____.
5. The breakdown of one molecule of glucose during respiration yields_____.
6. The functional units of lungs are called_____.
7. The muscles attached to ribs are called_____.

8. _____are the cells responsible for the clotting of blood.
9. _____are the cells in the blood that produce antibodies.
10. Arteries carry blood_____ _____ the heart while veins carry blood_____the heart.
11. _____is the chamber of the heart which pumps blood to all the parts of the body.
12. Loss of water in the vapour form occurs through_____parts of the plant body.
13. The ducts arising from the kidneys are called_____.
14. The nitrogeneous waste product in man is produced in the form of_____.
15. Fission is a common type of reproduction in_____organisms.
16. _____is an example of vegetative propagation by leaves.
17. _____is the part of the flower that develops into the seed after fertilization.
18. _____is the common passage for both urine and sperms in man.
19. Embryonic development occurs in_____in the females.
20. The entire period of internal development is called_____

CHAPTER 5

THE FASCINATING WORLD OF BIRDS

5.1. Introduction

Whenever you pay a visit to a park or zoo or a wildlife sanctuary, which group of animals fascinate you most? Undoubtedly, the birds. Why are you attracted by them so much? It is because they are among the most colourful and musical creatures inhabiting the earth. Birds cocur in every habitat, from polar ice to tropical deserts. Some have also adapted to live in water. Birds took to flight some 150 million years ago. They unlocked long, long ago the two prime secrets of any flying machine that is developed by man now, when they developed high power and light weight.

5.2. Origin of Birds

Birds had their origin from reptiles. They evolved from a group of small, terrestrial, two–legged, wingless dinosaurs. These reptiles are said to have developed feathers and taken to flying primarily to escape from their enemies and to exploit the new environment.

The oldest available fossil–bird is *Archaeopteryx* (Fig.5.1). This lizard–like bird was about the size of a pigeon. It had long jaws with teeth as in the present–day reptiles. It had a long tail covered by feathers. There were two wings supported by bones. This reptile–bird is said to have lived and flourished about 125,000,000 years ago, and is considered as the immediate ancestor of modern birds.

5.3. Unique Features of Birds

The birds differ from all other vertebrates in having certain unique characteristics.

- Birds have wings which are modified forelimbs.
- Birds possess the highest body temperature(about 42°C) which does not change with the environment. This is accompanied by a rapid rate of heart–beat. In some smaller species of birds, it may be up to 1,500 beats per minute.

Fig. 5.1 (A) Archaeopteryx Fossil; (B) Reconstructed Bird

* Birds have a high metabolic rate which yields plenty of energy. They require this energy for flying. This energy comes from the high–calorie foodstuffs that they consume each day. Their energy–rich food along with their tremendous metabolic efficiency, make it possible for birds to transform a third of their food into energy (Mammals can convert only one–tenth of their food into energy).

* Birds have a strong but light skeleton. Several bones have fused to make the skeleton stronger. Some bones have disappeared to make the skeleton lighter. Many bones are hollow and filled with air. Such bones are said to be **pneumatic**. The total weight of all the bones of a bird is less than the total weight of its feathers.

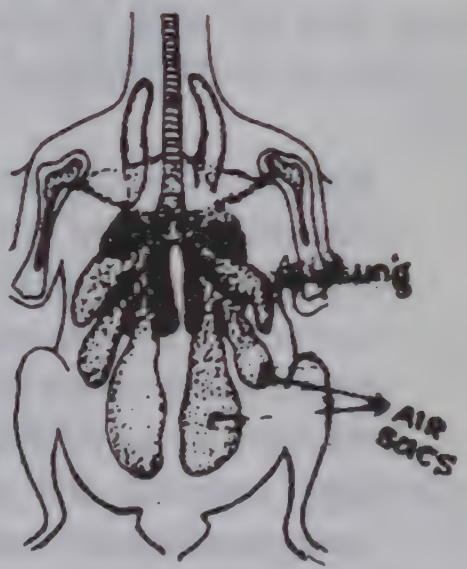

Fig. 5.2. Lungs and Air Sacs in Birds

* The birds are provided with air sacs which extend from lungs. They increase the efficiency of respiration. The respiratory system of birds

operates as an efficient cooling device. During respiration, two–thirds of the inspired air is used for cooling while the remaining one–third is used for breathing.

* The eye-sight of a bird surpasses that of any other animal. The eyes are marvellously constructed for both near and far vision. The vision of some birds is at least 200 times sharper than that of man.
* Birds have a right aortic arch.
* Birds produce hard, calcareous, shelled eggs which require incubation for hatching.
* The most novel feature of a bird is its exoskeleton formed by feathers. The feathers provide the warmest insulation in the animal kingdom.

Feathers : Feathers distinguish birds from all other vertebrates. They form a light, but effecient water–proof covering which keeps the body warm. On the upper side of the hind end of the body is an oil gland. You might have noticed some birds preening themselves by reaching to the oil gland by their beak. It is for smoothening the feathers with the secretion from the oil gland. It makes the feathers water–proof.

Feathers are not found all over the body. They occur in certain tracts and the bare spaces between them are covered by an overlapping of the feathers. There are four main kinds of feathers in birds :

1. **Wing feathers** or **quill feathers** are long and stiff. They have a central axis and an expanded part called **vane**. The lower part of the axis is hollow and forms the **quill**. The upper part of the axis is solid and is called **rachis**. It bears a number of fine processes called **barbs** which form the vane. The barbs are arranged obliquely on either side of the rachis like the teeth of a comb. Each barb has two rows of small branches called **barbules** arranged obliquely so that the barbules of the adjacent barbs overlap (See Fig.5.3). This overlapping provides a surface that is capable of beating air.

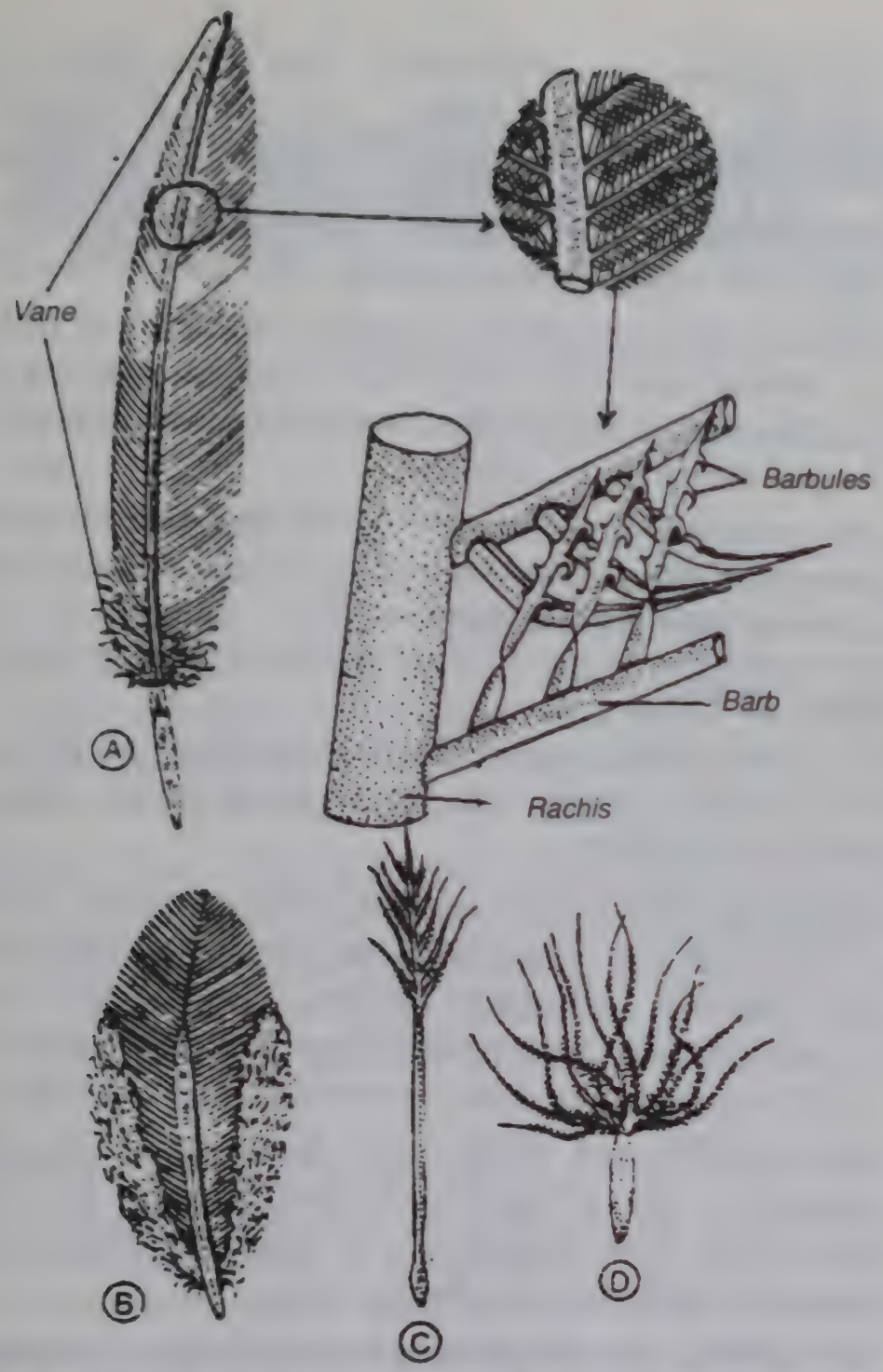

Fig. 5.3. Different Types of Feathers : (A) Quill Feather; (B) Contour Feather; (C)Filoplume; (D) Down Feather

Contour feathers that cover the body are more or less similar to the quill feathers, but their barbules are poorly developed. They vary very much in size and shape and mainly help in maintaining body temperature.

3. **Down feathers** are furlike in texture. They are inserted in the skin in between the contour feathers. Their barbs do not interlock. These feathers also help in maintaining the body temperature.

4. **Filoplumes** are hair–like feathers. They are found all over the body. They usually have a slender shaft with a tuft of barbs at the end.

The characteristic arrangement of feathers is known as **plumage**. It varies in different species of birds. Birds lose their feathers almost once a year, during the period called **molt.** In this way, the worn–out and damaged feathers are replaced.

Activity 5.1 : Collect feathers from different types of birds. Classify them as above and draw their diagrams.

5.4. Types of Birds

There are about 8,600 species of birds of which about 1,200 species are known to occur in India. The modern birds can be conveniently divided into two categories.

1. **Flightless Birds** : These are birds which cannot fly. They have either rudimentary or vestigial wings. The most familiar example which you can immediately recollect, is the ostrich. It is the largest living bird; it has powerful legs adapted for fast running. Its eggs are the largest in the animal kingdom. The other common flightless birds are Rhea, Emu, Cassowary, Kiwi and the penguins. The penguins are found only in the southern hemisphere. They thrive mainly by feeding on fishes which they capture by using their paddle–like wings.

2. **Flying Birds** : The birds which can fly can be grouped into several homogeneous groups such as :

Swimming and Diving Birds : These birds are both excellent fliers and spectacular divers. Pelicans, Cormorants and Garnels are fish–eating birds having fully–webbed feet Most have a pouch in the throat for storing fish. Birds like geese, ducks and swans have a spoon–shaped bill adapted for straining food from mud and water

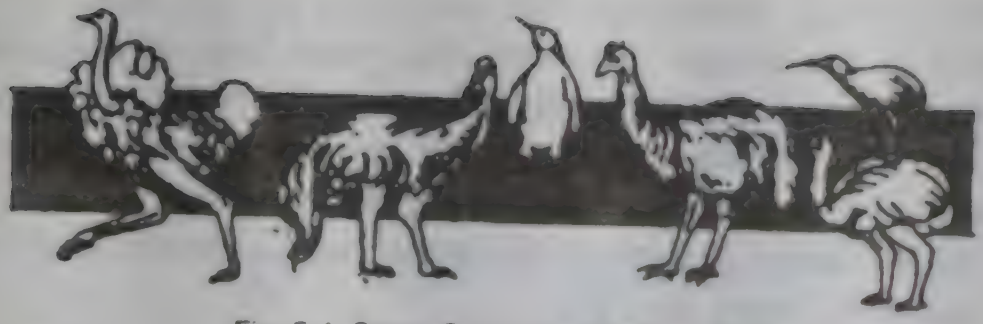

Fig: 5.4. Some Common Flightless Birds

Kingfishers feed on small fish and amphibians by diving headlong into water.

Shore and Wading Birds : These birds live in an aquatic habitat but only a few can swim or dive into water. Gulls have toes webbed at least at the base. Legs are long and are used for wading. The elongated bills help in probing the mud. Storks, herons and flamingoes have long snake–like neck and javelin–like beaks for grasping their aquatic prey. Cranes have discontinuous webbing on the toes. Beaks are usually lance–like and used for catching the prey.

Birds of Prey : These are carnivorous predatory birds which feed on the flesh of other animals. Hawks, eagles, vultures and owls belong to this category. The beaks are suited for tearing flesh. Feet have powerful claws. Owls can be distinguished by their larger head, broad eyes directed forwards and feet covered with feathers up to toes. They are nocturnal.

Arboreal Birds : These birds spend a major part of their life on and around shrubs and trees. A large number and variety of birds fall into this group. Most of the common birds that you see in and around your place, namely, sparrows, crows, fly–catchers, swallows, woodpeckers, parrots, doves, pigeons, etc. are in this group. There is no uniformity in their size, beak structure and food habits.

Aerial Birds : These birds spend most of their time flying. They usually perch only when they rest. Their feet are weak and in some cases, vestigial. The swifts and humming birds are remarkable fliers. Humming bird is the smallest and the most active bird.

Terrestrial Birds : These birds spend a great of their life walking or running on the ground and prefer to fly only in emergencies. The

chickens, turkeys, pheasants and partridges are the most common examples of this group. All these birds have their bills specialised for omnivorous diet. Their feet are well adapted for walking and running and have powerful leg muscles. The thoracic muscles are poorly developed and they cannot help in long distance flights. Almost the entire poultry industry depends on these birds. Hence, they are of great economic value to man.

Activity 5.2. : Collect photographs of pictures of different birds and classify them as discussed above.

5.5. Beaks and Feet in Birds

Birds feed on a wide variety of organic food rich in energy. It includes seeds, nuts, fishes and flesh of other animals. As a result, birds show suitable adaptations for feeding on these diverse source of food. Modifications of the beak to suit the different modes of the feeding are especially conspicuous. Look at Fig. 5.5. You will see some modifications in the beaks of some birds. Try to correlate these modifications with their feeding habits with the help of Table 5.1.

Table 5.1 Modifications of Beaks in Birds

Type of Bird	Type of Food	Type of Beak	Special uses
Crow (omnivorous)	A variety of food	pointed Strong tearing the food	For pecking Food
Sparrow	Seeds and grains	Short, stout and straight	For crushing the food
Eagle, Hawk, Owl	Flesh of animals	Hooked	For killing prey and for tearing off strips of fesh
Parrot	Hard seeds	Hooked	For cracking seeds (may be used for climbing also)

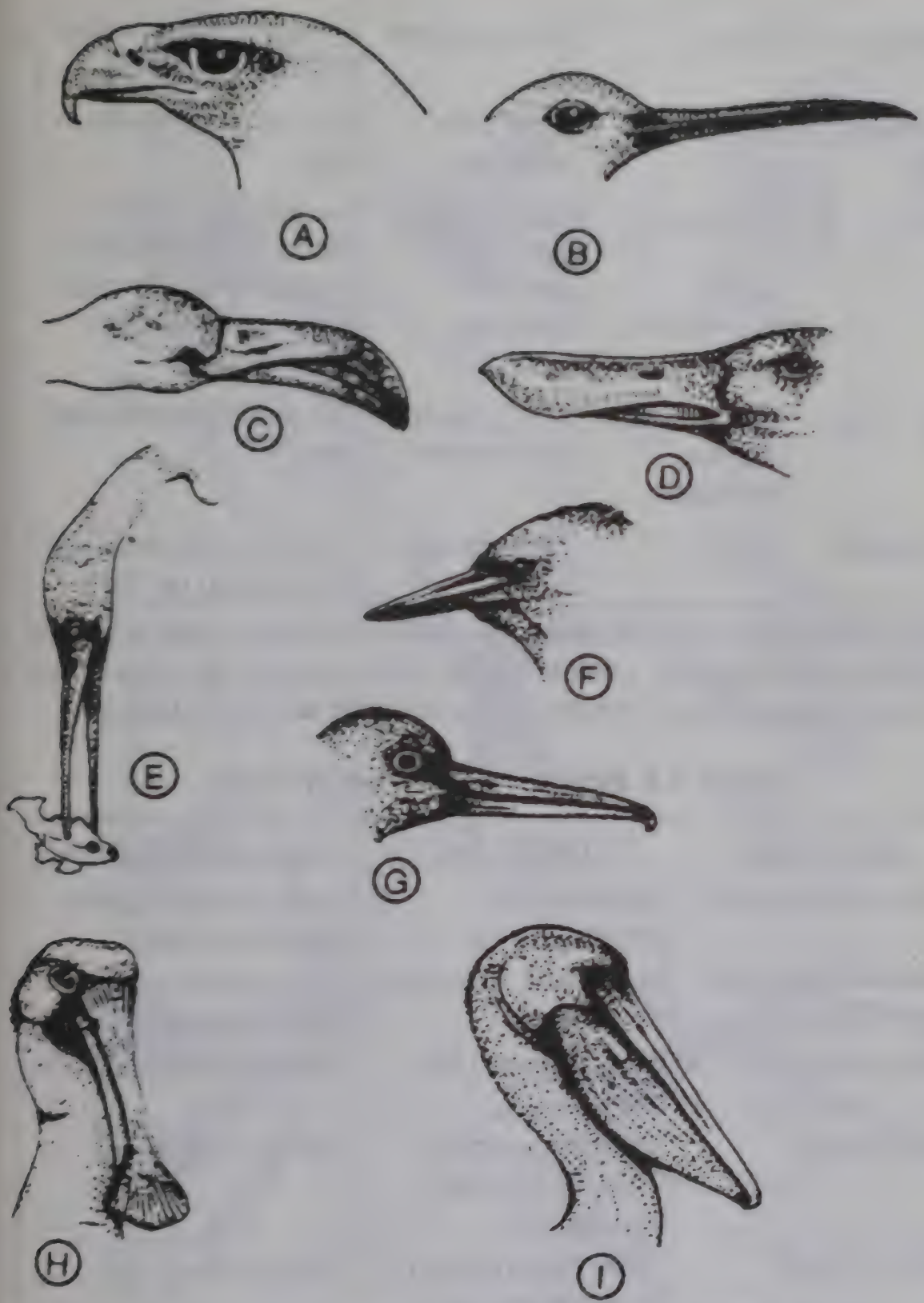

Fig. 5.5. Modifications of Beaks in Birds : (A) Eagle: Tearing; (B) Stilt: Mud Probing; (C) Flamingo and (D) Duck: Mud Straining; (E) Snake Bird, (F) Kingfisher and (G) Cormorant: Capturing and Gripping; (H) Spoonbill: Holding Small Organisms; (I) Pelican: Capturing and Storing Fish

Woodpecker	Insects	Short, narrow	For picking the insects from cracks in bark
Swallow, Swift	Insects	Short with wide gap	For catching insects in flight
Duck	Frogs and other edible animals in water	Flat, grooved and ridged on inner surface	For gripping slippery animal, taking beakful of water from the mud (used as strainers)
Ibis, Snipe	Worms and aquatic creatures	Long, narrow and curved	For probing earth and mud
Kingfisher	Fish	Straight and sharp	For plunging into water and picking up fish.

The feet of birds may also become modified to suit the mode of feeding or locomotion of the bird. Look at Fig.5.6 Try to correlate the type of feet with the mode of living of the bird. The following table may help you.

Table 5.2. Modification of Feet in Birds

Name of Bird	Type of feet	Uses of Modification
Eagle,,Vulture, Owl	Toes end with powerful claws	Used for siezing and holding the prey
Domestic fowl, and game birds	Strong feet, toes with blunt nails	For scratching in the earth in search of food
Duck, Geese	Webs between the toes	For swimming in water
Woodpecker	Two toes pointing forwards and two backwards	For climbing trees
Pigeon, Finch	Three toes pointing forwards and one backwards ending in claws	For perching

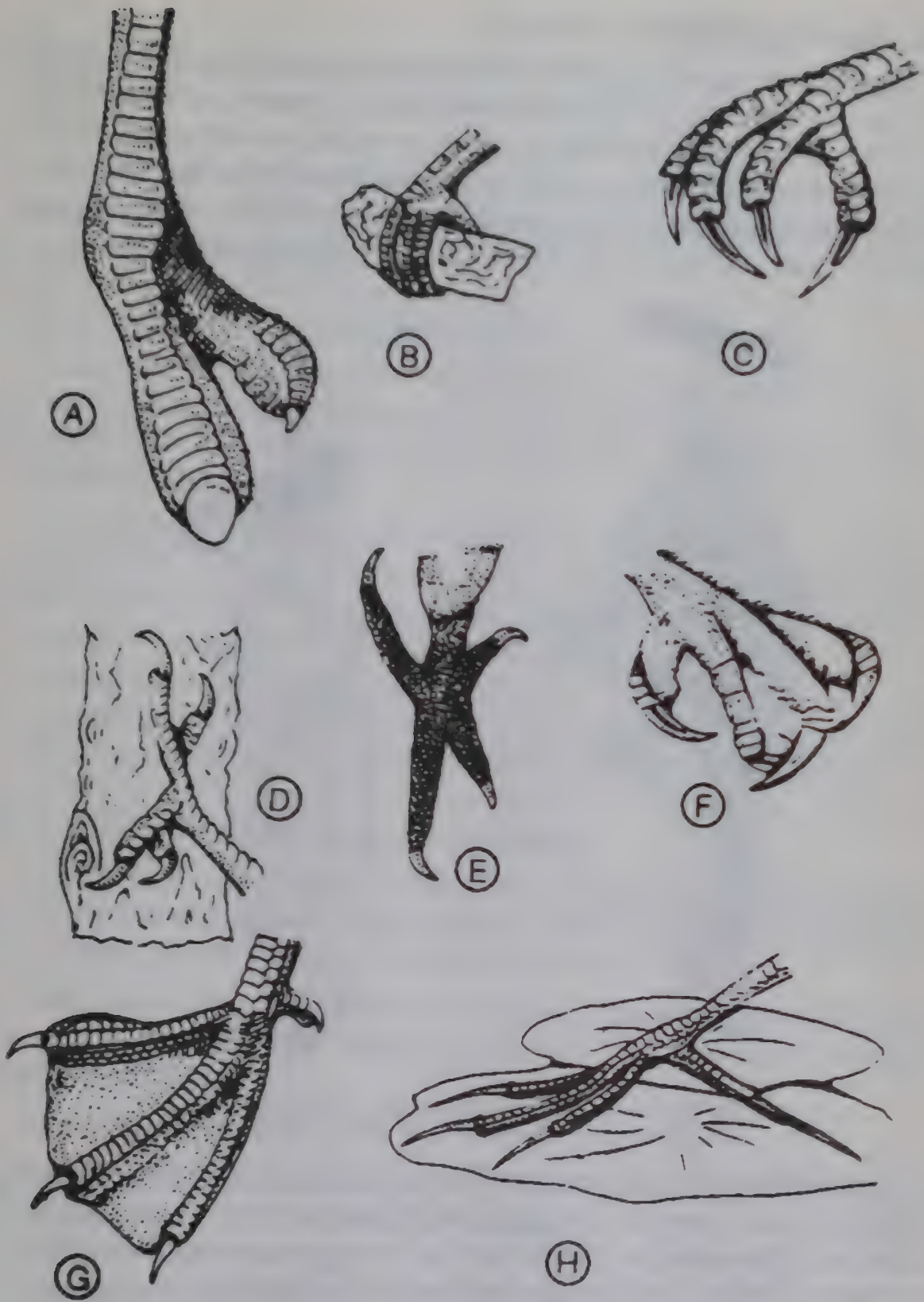

Fig. 5.6. Modification of Feet in Birds: (A) Ostrich: Cursorial Running (B)Finch and (C) Sparrow: Perching; (D) Woodpecker and (E) Parrot: Climbing and clinging; (F) Owl:Grasping; (G) Duck: Swimming; (H) Jacana: Wading and Leaf–Walking

5.6. Nesting Habits in Birds

Another interesting way of life in birds is their nesting habit. The nests are as characteristic as the birds themselves. There are birds which build nests on trees, on floating debris in water, on cliffs and so on. There are birds which lay eggs in the nests of other birds also. You must have heard about koel laying its eggs in the nest of crows. The penguins lay their eggs on the ground, without constructing any nest at all.

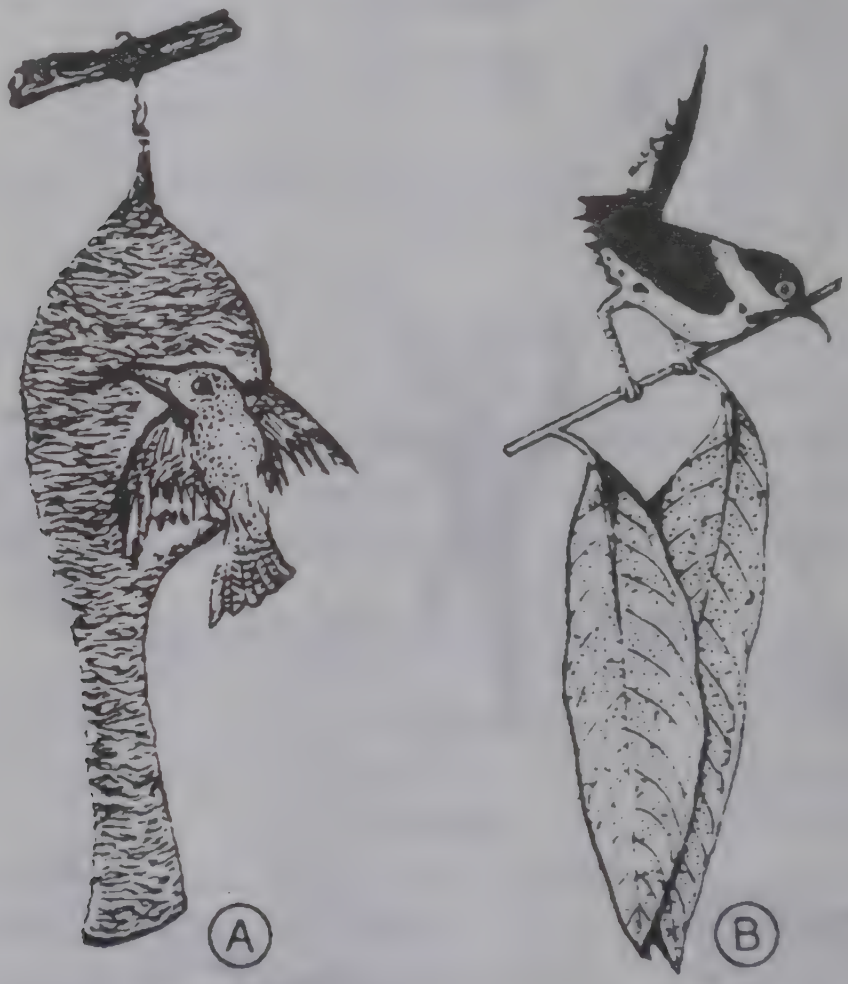

Fig. 5.7. Nests of (A) Weaver Bird and (B) Tailor Bird

The weaver bird builds the most intricate nest, using coconut fibres or paddy leaves. The nest hangs downwards from the branches of trees. It has two chambers, and upper one for the eggs and the lower used as entrance. Sometimes, the nest may be illuminated by glow–worms.

Tailor birds build nests using two broad leaves. The male bird makes holes along the margin of the leaves with its pointed beak, while the female passes string like materials through these holes. Thus, the

leaves are sewn together in the form of an elongated pocket. It is filled with a bed of soft materials, and then the eggs are laid.

Activity 5.3: Collect the empty nests of some birds from the surroundings of your house. Examine the materials used by the birds for building these nests.

5.7. The Riddle of Bird Migration

Birds move from one place to another covering long distance. This is known as **Migration**. Birds migrate in search of food or breeding places. Normally birds migrate from a region of feeding and resting to a region of breeding and nesting.

The champion of all animal navigators is the arctic tern. It travels about 30,000 to 35,000 kms every year. It nests in the treeless, arctic region and rests in the antarctic region. Every year it returns to the same nest which it used in the previous spring.

Activity 5.4 : Visit a bird sanctuary near your place of living, along with your teacher or parents. Try to identify some migratory birds.

5.8. Economic Importance of Birds

The greatest use of birds to man is their food value. Several kinds of birds are domesticated for the purpose of obtaining their flesh and eggs. This Rearing of birds yields a tremendous annual revenue.

The guano deposits which are formed by the excreta of birds, are used as a major source of fertilizer. They are also the source of nitrates used in explosives.

Birds help in the destruction of insect and rodent pests.

The feathers of birds have always been an object of attraction to man. Feathers are used for stuffing pillows, blankets, clothing and caps and for many decorative purposes. The downfeather of water birds, such as ducks and geese, provide the warmest insulation and are used extensively for arctic clothing and for subzero sleeping bags.

The aesthetic value of birds has provided a never–ending source of recreation for bird watchers all over the world. The cheerful songs and the interesting activities of birds have provided a much–needed natural

tonic for the citizens of the world. Bird watching is becoming an interesting and popular hobby.

Activity 5.5: You can start a nature club in your school and keep *bird watching* as one of its regular programme. Take the assistance of your teacher and the local bird watchers' club.

EXERCISES

I. Answer the following questions:

1. Write a brief note on the origin of birds.
2. Describe any four unique features in birds.
3. Write a brief note on feathers in birds.
4. With the help of neat labelled diagram describe the structure of quill feather.
5. Name the two major categories of birds with two examples for each.
6. How are the beaks and feet modified in the following birds to suit their mode of feeding : (i) Sparrow (ii) Woodpecker (iii) Duck (iv) Owl?
7. Describe the nests of (i) Weaver bird (ii) Tailor bird.
8. Write a brief note on bird migration.
9. Mention the uses of birds to mankind.
10. Draw neat diagrams of the beak and foot in the following birds: (i) Pigeon (ii) Humming bird (iii) Hawk (iv) Duck.

II. Name the following:

1. The Earliest fossil bird.
2. Long and hollow bones of birds, filled with air.
3. Feathers which are furlike in texture.

4. Birds found only in the southern hemisphere.
5. Two predatory birds.
6. The largest bird and the smallest bird.
7. A bird which builds its nest with two chambers.
8. Our national bird.

III. Distinguish between the following:

1. Penguin and Pigeon
2. Quill feather and Contour feather.

IV. Fill in the blanks:

1. Birds had their origin from_____.
2. In birds the aortic arch is on the_____side.
3. The wings of a bird are modified_____.
4. Rhea is an example of a_____bird.
5. _____is the longest non–stop migrant bird.

Unit II : Human Beings

CHAPTER 6

THE STORY OF MAN

6.1 Introduction

Man, like any other animal, is a product of the process of organic evolution. He holds the unique distinction of being the most recent and, at the same time, the most intelligent vertebrate of evolution on this planet. The supremacy of man stems mainly from the evolutin of his hand and his brain. He is the only animal to have developed brain power and capacity to use hands to make and use tools, and to develop an intricate oral and written language for communication.

6.2 Ancestors of Man

Human beings belong to a group of mammals called **primates**. Our closest living relatives are the gorillas and chimpanzees. We share a number of anatomical and biological characteristics with animals variously called monkeys, apes, baboons, lemurs and tarsiers, placed in the group primates. Some of the obvious characteristics which we share with other primates are:

* reduced snout with most of the skull posterior to the eyes.
* eyes directed forwards with highly–developed binocular vision.
* presence of five functional digits in forelimbs and hindlimbs.
* enhanced mobility of digits, especially the thumb, which can oppose other digits.
* claws modified into flattened nails.
* enlarged brain, particularly the cerebral cortex.
* only two mammary glands to nourish the young ones, and
* typically only one offspring (generally) in each pregnancy.

In the year 1871, the famous biologist Charles Darwin published the book, *The Descent of Man*, in which he noted the similarities between man and apes and suggested that they have a common ancestor. Long

before Darwin's period, taxonomists had placed man in the genus *Homo* of the family **Hominidae** in the order **Primates.**

Fig. 6.1. Some Common Apes

Initially, in the absence of any fossil evidence, the tracing of human ancestor was based only on the study of living primates. The more biologists continued to study primates and man, the more the two were found to resemble each other. The resemblances were more striking in the case of gorilla and chimpanzee. For example, recent studies have shown that the haemoglobin of man and gorilla differ only in one amino acid. Such studies only indicate that man must have shared a common ancestor with all the primates, long, long ago.

While the data from the study of living primates could only suggest what **might** have happened in the course of evolution, the study of fossils of several primates and primitive men could tell what actually **did** happen. Such studies have helped man in knowing his own past.

6.3. The Biological Evolution of Man

Mammals first made their appearance in the middle of the mesozoic era, much before dinosaurs became extinct. Very early, a line of insectivorous mammals called shrews, which are known today only from

he could hold and manipulate them using his flexible hands. This form of **pre–man** has been named **Zinjanthropus**.

Ramapithecus, one of the descendant branches of pre–man, appeared about 13 to 14 million years ago. It is considered as the true ancestor of the modern man. Though it is known only from the fossils of its face and jaw bones, Ramapithecus is presumed to have had a wider distribution, turning up in both Africa and Asia. The remains of such a primate were obtained in the Siwalik range of our country also. In fact, in the name *Ramapithecus*, 'Rama' signifies that it belonged to Indian peninsula; and 'pithecus' means ape. Shortly after this period, shifts in the earth's crust and changes in the climate resulted in the conversion of large areas of forests into dry grasslands. Such changes in the environment are presumed to have accelerated the evolution of our early ancestors.

About five million years ago, a descendant of *Ramapithecus*, appeared in the drier regions of eastern and southern Africa. It is called **Australopithecus**, meaning 'southern apes'. These primates, regarded as 'first humans', were relatively short, about $4^{1}/2$ feet in height. The forehead was low but had a brain capacity almost equal to that of the much taller modern gorilla. They walked erect, hunted in groups and perhaps used pebbles and bones as tools. The cranial capacity of these primates was only about one–third of the modern man.

The Australopithecans gradually evolved into distinctly human–like forms that have now been placed in the genus ***Homo***. The oldest known fossil skull of this genus is about 2.5 million years old. This creature is assigned the name ***Homo habilis***. It had a cranial capacity of about 700 cc. Limb bones almost resembled the bones of modern man. These early men are supposed to have used tools and weapons.

About 1.5 million years ago, ***Homo habilis*** evolved into a more modern form, ***Homo erectus***. These individuals are said to have gradually spread all over the world. The so–called 'Java man' and 'Peking man' belong to this group. The first discovery of 'Java man' was made in the form of a skull by a Dutch anatomist, Eugene Dubois, in 1891. Later finds of this type in Java (an island of Indonesia) revealed parts of fossils

of a number of individuals, including that of a child. A few crude stone tools were found near these fossils. In 1924, fossils similar to those of Java men were unearthed in Peking (China) by a team of Canadian biologists. This led to the discovery of the 'Peking man'. During the next twelve years, fossils of body parts of about forty individuals were unearthed from a cave floor near Peking. A whole array of 'chopping' tools (rough stones chipped to an edge on one end, like a modern chisel) were found along with the skulls. Charcoal was also found nearby, indicating that Peking man was using fire.

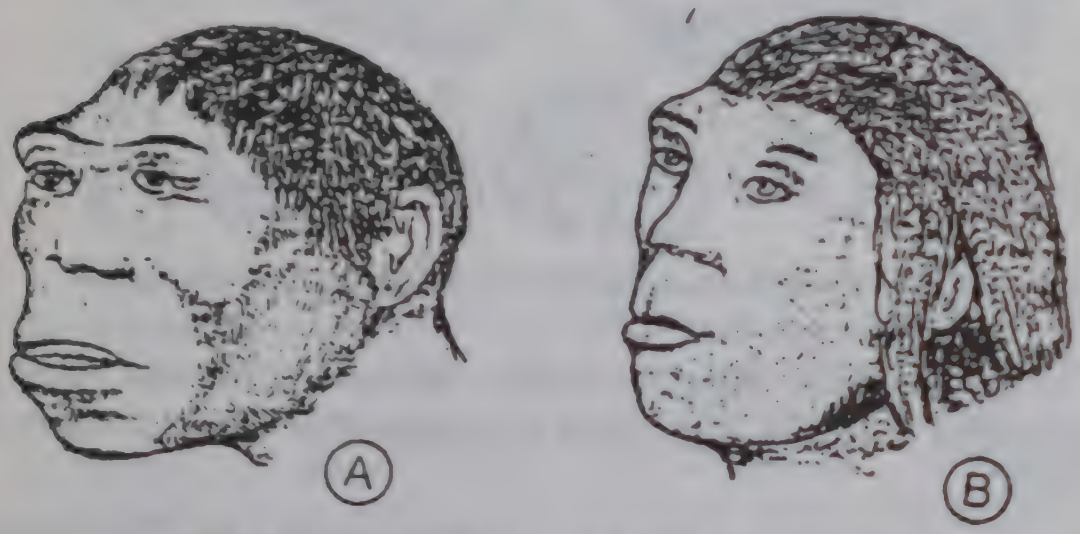

Fig. 6.5. Homo erectus : (A) Java Man; (B) Peking Man

About 2,50,000 years ago, the species ***Homo erectus*** was gradually replaced by *Homo sapiens*, the species to which the modern man belongs. The individuals of this species showed a larger brain capacity than their ancestors'. Their intellectual capacity was much higher. These humans developed sophisticated tools and weapons. They also developed language.

The earliest form of ***Homo sapiens*** is known by the name ***Neanderthal man.*** He appeared in Eurasia and northern Africa, just before the beginning of the last glacial advance. He was rather short, heavily built and exceedingly strong. Like ***Pithecanthropus*** (Java), he had heavy brow ridges above the eyes. The jaws were protruding, chin was small and the forehead sloping. Neanderthal man made excellent tools and buried his dead fellowmen with considerable ceremony.

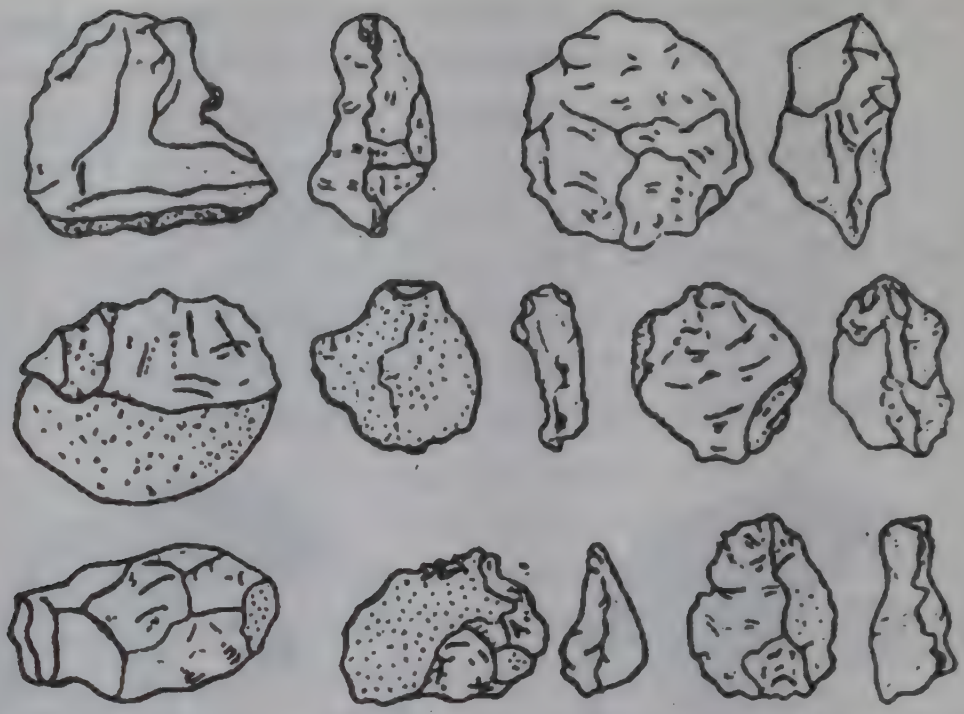

Fig. 6.6. Some Forms of Stone Tools Used by Early Men

He is presumed to have developed speech. The first fossil of Neanderthal man was discovered in Neanderthal valley of Germany in 1856.

The Neanderthal man is said to have disappeared about 50,000 years ago, during the last glaciation. Various theories have been proposed to explain the causes of his extinction. Probably he was overpowered and replaced by men very similar to ourselves. Perhaps, the Neanderthals might have intermated with the newcomers; or they were exterminated because of their inability to compete with a culturally more advanced type of men, armed with better tools and weapons.

The successors to Neanderthal man were a group of early men known as **Cro–magnon.** The first fossil was detected in a cave near a place called Cro–Magnon in France. The Cro–magnon man is presumed to have lived around the end of the ice age, about 30,000 years ago. He was active, intelligent and presumably, had a large stature. The Cro–magnon people lived in a world inhabited by a wide variety of mammals such as woolly mammoths, rhinoceros, bisons, wolves, wild horses and bears. They made superb paintings of these animals within the caves of France and Spain where they lived. They used finely–chipped stone arrows and spear points. They carved tools and ornaments from ivory.

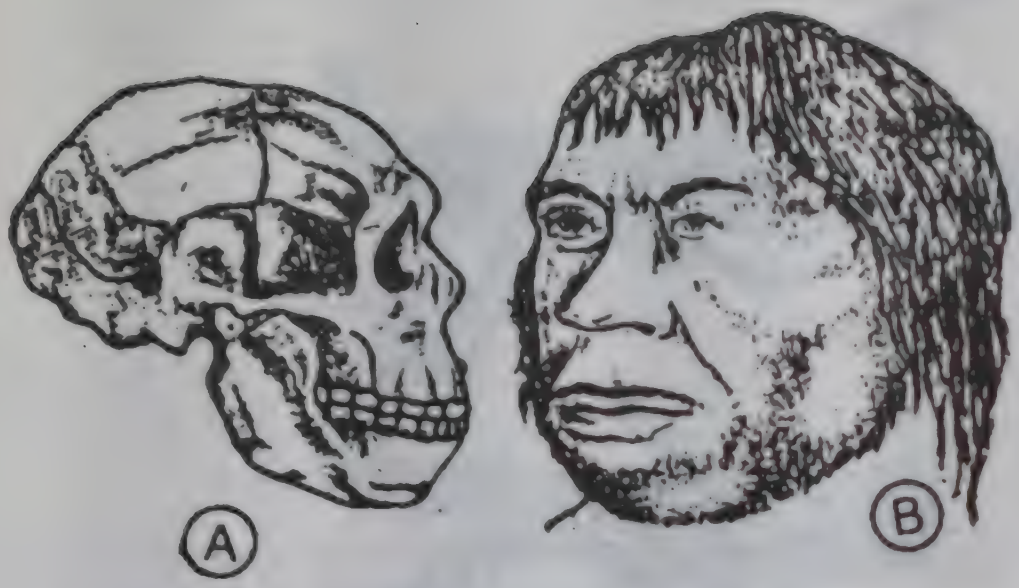

Fig. 6.7. Homo sapiens–Neanderthal Man: (A) Skull; (B) Face Restored

Modern man is not very much different from Cro–magnon man, in terms of biological evolution. It is only the cultural evolution that sets him apart. Culturally, modern man is more advanced. He is capable of thinking, memorizing, speaking, reading and writing. He has developed agriculture and started domestication of animals. He has learnt to manipulate nature according to his needs. He has developed science

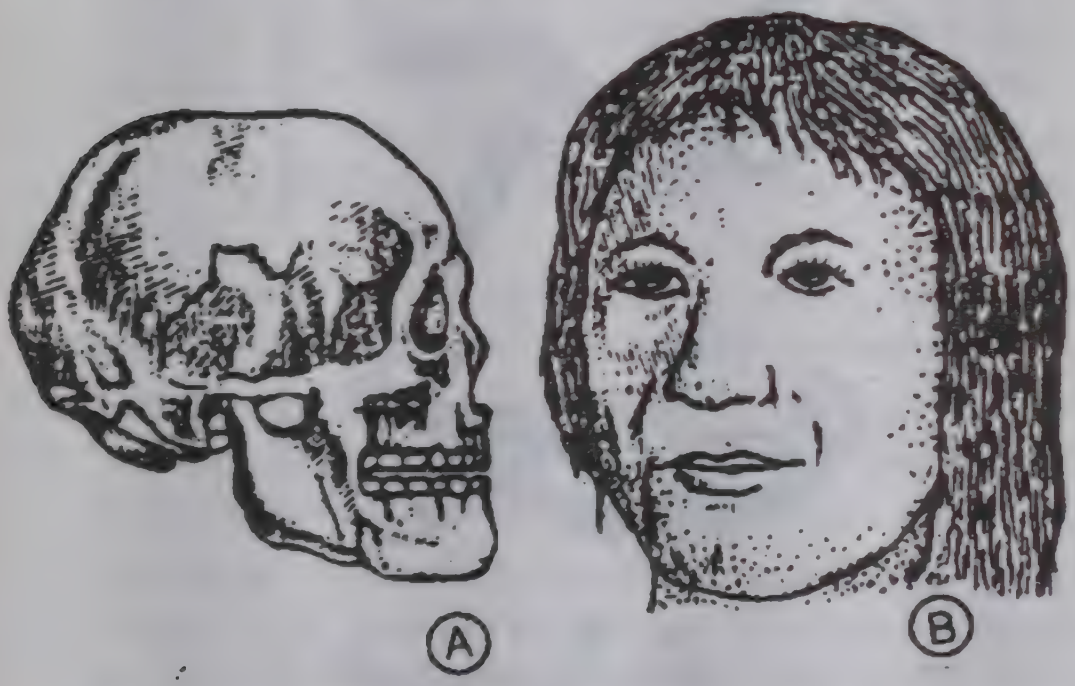

Fig. 6.8. Homo sapiens–Cro–magnon man : (A) Skull; (B) Face Restored

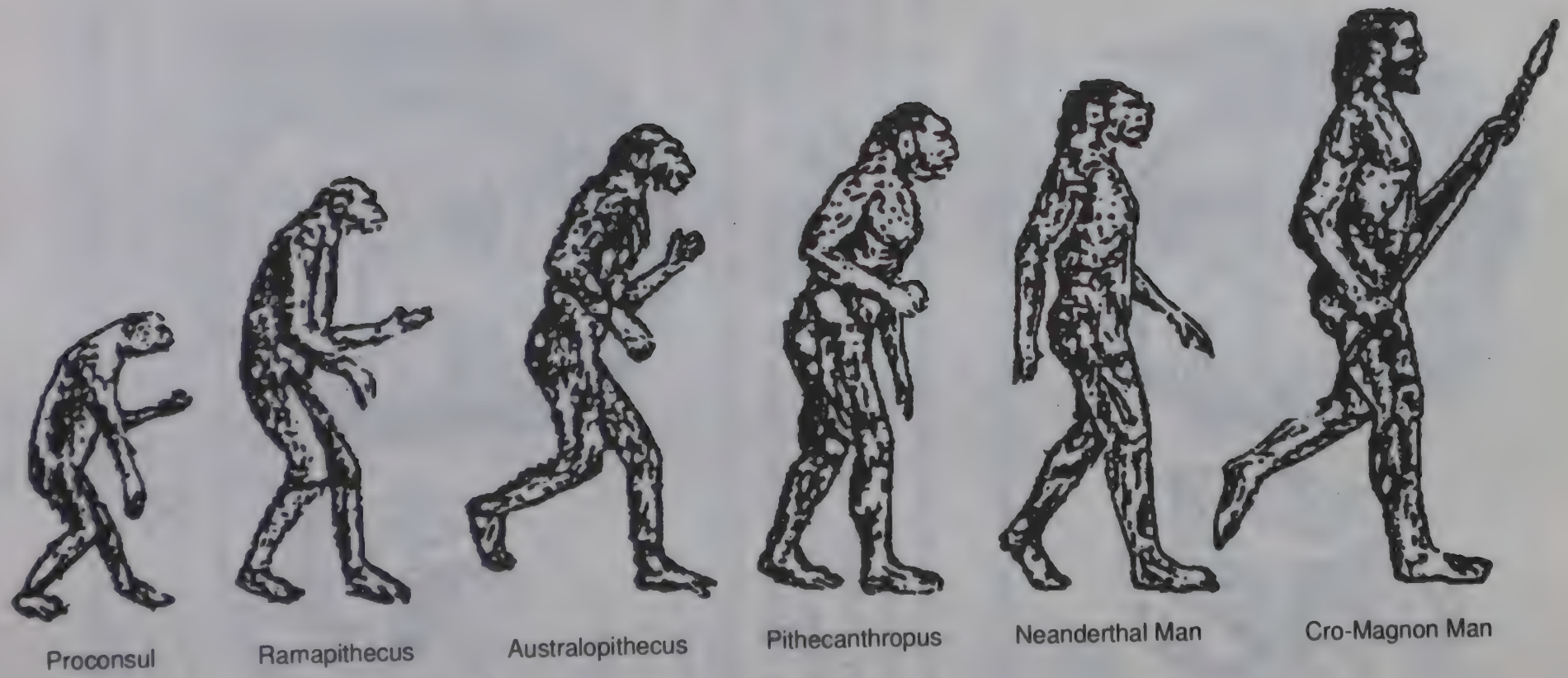

Fig. 6.9. Road to Homo sapiens

Fig. 6.10. A Painting done by Cro–magnon Man

and technology as a result of his intelligence. He has emerged as the most dominant creature on this planet, earth.

6.4. Human Races

When you look at the different groups of human beings inhabiting various countries, you may wonder as to how these different–looking individuals fall in the same species – ***Homo sapiens.***

Many noticeable variations exist among the groups of modern man such as colour of the skin, hair and eyes, shape of the nose, thickness of the lips, the texture and distribution of body hair and blood groups. Based on such variations, anthropologists (scientists who specialize in studying man) have classified human beings into subdivisions called stocks or **races**. These subdivisions have resulted mainly due to a long history of geographical isolation, extending perhaps to about 25,000 years.

In general, there are five human races, namely, 1. Caucasoids, 2. Mongoloids, 3. Congoids, 4. Capoids and 5. Australoids.

Caucasoids are generally characterised by light skin, blue or dark brown eyes, high ridged nose with narrow nostrils and wavy or straight hair. They live in Europe, India and certain parts of America.

Mongoloids are characterised by yellowish or reddish brown skin, hairly thick lips, wider nose and straight hair. They include the people of China, Japan, Mongolia and Malaysia, besides Eskimos and American Indians.

Congoids are characterised by skin, woolly hair, thick lips and broad nose. They are also called Negroids. They occur mostly in central and South Africa and include the Negroes and Pygemies.

Capoids have a black or brown skin. They are very simple and shy people. They include the bushmen of Africa.

Australoids have a brown skin, curly hair and deep eye sockets. They are the original inhabitants of Australia.

However, anthropologists recognize that each of the features by which the races can be identified as above, show considerble variations within any given population.

The human races do not genetically differ very much from one another. This is evident from the fact that humans of different races are able to mate and produce fertile offspring. The races are mainly social categories by which people identify each other.

The races of mankind will gradually lose their identity as a result of expanding populations and also minimised isolation.

Activity 6.1 : Collect the pictures of men from different countries. Try to identify the races to which they belong.

6.5. Cultural Evolution in Man

The attainment of an upright posture in the earliest human beings necessitated the use of tools. We still cannot state with confidence, which came first–man's enlarged brain or his development of tools and culture? Sometime between 50,000 and 75,000 years ago, the gradually evolving populations of mankind reached the stage when they were biologically like the modern man. About 25,000 years ago, the ancient men developed some of the abilities that made modern life possible.

These were the abilities to make and use tools, to communicate, to teach the younger generations, to work together, to respect wise and intelligent, leadership and to look to the future for a better life. It is the fruits of these benefits that have become the story of mankind.

Based on the evidences available in the form of fossils and discarded tools of ancient men, the following stages can be recognized in the human cultural evolution.

Hunting and Food Gathering : The first stage in the cultural evolution of man began with the **nomads**, who lived some 10,000 to 25,000 years ago. They probably cooked their food on open fires. The discovery of fire was a major landmark in the story of human evolution. Since game animals and edible plants became scarce from time to time, these ancient men could not always live a settled life. They had to move from place to place very often, in search of food.

The Dawn of Agriculture : The second major step in man's cultural evolution is the development of agriculture. It is believed to have happened some 10,000 years ago in Eurasia. The dawn of agriculture laid the ground for the rise of civilization and favoured the conditions that made a settled life possible. The remains of men who lived about 7,000 to 10,000 years ago, have included hulls of grains similar to modern wheat and barley, along with tools like sickles which were probably used in harvesting plants.

Several skills had to be learnt by men of that period for raising sufficient crops to support themselves. They had to learn **which** seeds could be sown and which would grow quickly into mature plants. They also had to learn **how** to clear the land and how to dig it up, so as to make the soil become loose and well–aerated. Next, they had to learn **when** to plant, so as to avoid conditions of the environment which would harm or kill the seedlings.

In addition, the early men also had to devise methods by which they could keep away the destructive animals that would attack these plants. They also had to defend their crops from other tribal people who had not yet started the practice of agriculture. Finally, they had to learn how to harvest the crop quickly and store it for future use. Gradually, the early men learnt all these and even tried to improve upon the crops. This involved conscious, **artificial selection** of crops that were much different from the ones that grew in natural conditions. It is as a result of such an artificial selection of characteristics that our cultivated food plants have come to differ from their wild relatives.

Domestication of Wild Animals : The next stage in the cultural evolution was perhaps the domestication of animals. It must have

involved much more than merely capturing some animals and keeping them. Dog is the first animal that is said to have been domesticated by early men. They must have probably begun by raising the young animals with them, so that, as they grew up, they could be tamed and even bred in captivity.

The Beginning of Settled Life : The observations made on the remains of serveral ancient human settlements have suggested that the first people who settled down were the primitive fishermen. Many of them were presumably poor hunters and did not cultivate plants. Since they mainly lived along the sea–shore or banks of lakes and rivers, they were obtaining most of their food by fishing or gathering shell–fish. Fishing hooks have been found among the tools in the remains of settlements that existed even before the dawn of agriculture. It was natural for any tribe to settle down in a particular place, if it was suitable for fishing. This was particularly true in the tropics where the supply of fish and edible plants was inexhaustible at that time.

Clothing : The early men of Europe made their clothing from the skins of the animals that they had killed. By the time of Cro–magnon man, the animal hides were cut and sewn together with strings of raw hide, just as Eskimoes make their clothes today. The remains of Cro–magnon man have shown bone needles among the tools that were used by him. These bone needles, presumably, were being used for sewing the hides.

Gradually, clothing became the most vital need of primitive men, next only to food. The concept of clothing took an entirely new turn with the invention of weaving. The weaving of cloth is perhaps as old as agriculture, having its origin in Egypt and Mesopotamia. The strong fibres of some flax plants were woven to form stiff linen. Wool and cotton fibres were inventions of a much later date, since both these involved the more difficult task of spinning short fibres into long threads.

The Rise of Civilization : The problem of staying and settling in one particular place was solved with the dawn of agriculture, as food supply was assured. Now, it was the time for organization in the settlement. This led to the rise of civilization. Organization in the settlement basically involved division of labour among the individuals. Available evidence shows that the first organization of this kind began under the direction of a powerful leader. When land became the source of food through agriculture, owning land became, perhaps, the way by which one could gain power and dominance over the others. This must have also led to the formation of social groups called families. Gradually, the

leaders of such large families became the local 'kings'. Division of labour gradually led to the formation of categories such as artisans, tradesmen, soldiers, priests and so on. Possibly in this way the first great civilizations in Egypt, Mesopotamia and the Indus valley of western India came into existence.

Table 6.2. Stages in Cultural Evolution from Stone Age to the Present

Name of the Age	Period	Development of Culture and Technology
Old Stone Age	Between 25,000 and 12,000 years ago	Food gathering and hunting, use of tools, use of fire and cooking
New Stone Age	Between 12,000 and 6,000 years ago	Settlements, agriculture, domestication of animals. New hunting techniques, stone arrows, daggers, wheel and pottery.
Copper Age	6,000 to 4,000 years ago	Discovery of minerals like zinc, lead and tin, use of copper alloys. Invention of sailing ship, wheeled carts.
Bronze Age	4,000 to 3,000 years ago	Establishment of villages, use of cotton and wool to make clothes, ornaments made of copper and bronze, carpentry, masonry and other trades. Barter system of trade.
Iron Age	Around 1,800 A.D.	Rapid development in science and technology. Invention of microscope, telescope, steam engine, etc.
Steel, Plastic and Atomic Age	Present period	Use of steel and plastic in place of other metals. Invention of T.V., computers, robots, superconductors, atomic power, nuclear reactors, etc.

6.6 Man as a Discoverer and Inventor

The study of cultural evolution in man has given the idea as to how man emerged from his primitive life to a modern civilized life. Civilization led to an increase in human needs. The increased needs, in turn, have made modern man a discoverer and an inventor.

The most important quality that distinguishes man from other animals, is his inventive nature. It is an ability to combine the skills of brain and hand. During the million of years of evolution, animals have become adapted in various ways to the changing environment. Animals have become adapted to cold weather through a process of natural selection by encasing their body in fat. But man has become adapted to cold by learning how to make and wear warm clothes. He provides a new environment for himself in which he can function normally even in severe cold. Birds and bats are able to fly because they have evolved great changes in their forelimbs and other structures. Man, on the other hand, with his unaltered body, has succeeded in flying by inventing machines which he can operate and which can carry him faster and farther than any bird.

Cultural evolution, to a great extent, depends on the transmission from one generation to another, of all that has been learnt, discovered, invented or created by man. The modern industrial society has come to depend more and more on the technological advances that stem from scientific discoveries and inventions. Science is advancing so rapidly that it is becoming an essential part of present–day life.

EXERCISES

I. Answer the following questions :

1. List the important characters that human beings share with primates.
2. Which was the mammalian group that gave rise to primates? What were the significant changes that occurred during this evolution?
3. Which was the earliest ancestor of apes and human beings? When did it exist?
4. Describe briefly the major stages in the biological evolution of man.
5. Write a note on the Neanderthal man.

6. Why do you consider that Cro–magnon man was the most intelligent among the early men?
7. List the stages in the cultural evolution of man.
8. The invention of agriculture changed the way of life of human beings. Justify the statement.
9. List the major human races.
10. What is the unique quality in modern man that distinguishes him from his ancestors?

II. Arrange the following in the correct sequence :

1. Homoerectus, Ramapithecus, Homo sapiens, Australopithecus, dryopithecus.
2. Agriculture, Civilization, Hunting and gathering, Domestication of wild animal, Settled life.

III. Distinguish between the following :

1. Java man and Modern man
2. Ramapithecus and Dryopithecus
3. Caucasoids and Mongoloids
4. Congoids and Capoids

IV. Fill in the blanks :

1. The remains of Ramapithecus have been obtained in_____of India.
2. The Cro–magnon man lived about_____years ago.
3. Indians belong to_____race of human beings.
4. The first animal to be domesticated by early man is presumed to be_____.
5. The first sign of development of agriculture occurred in about_____years ago.

CHAPTER 7

THE HUMAN BODY

7.1 Introduction

The study of human body has been one of the most fascinating subjects for scientists. Perhaps, the first examination of human body was done in ancient India, about 2,500 years ago. Sushrutha, as early as in 500 B.C., had explained how a detailed study of the human body could be made by keeping a corpse immersed in water for about a week. He had made his observations on different parts of the human body. The descriptions given by Sushrutha then have been found to be accurate by anatomists of recent years. Human anatomy, the science that deals with the study of internal structure of human body, however, owes its origin to an Italian, Andrews Vesalius, who made the first scientific examination of the human body in 1543. Since then, a lot of information has accumulated on the structure and functioning of the various organs of the human body.

With the accumulation of more and more knowledge on the structural aspects of the human body, scientists started comparing these aspects with the information available on related groups of animals. Such a comparative study showed that man is basically a mammal, but with some unique features. An evolutionary biologist, Stephen Jay Gould, has remarked, 'Mankind stood up first and got smart later'. Many of these unique features, developed in the course of evolution, have been advantageous. At the same time, some have conferred certain disadvantages on him.

Let us examine some of the unique features of the human body and the structural limitations imposed by them.

7.2 Unique Features of Human Body

The following features stand out as unique to human body, compared to other mammals.

1. Posture : Man differs anatomically from all other mammals primarily in having a totally erect posture. In this respect he is even set apart from other primates like apes which are semi-erect. The **erect posture** has set the forelimbs free from the task of locomotion and he has become **bipedal** in locomotion. The foot bears the entire weight of the body.

In primates like apes the foot can grasp or hold objects just like their hands. The hands of an ape are longer and reach beyond the knees. But man's hands are shorter.

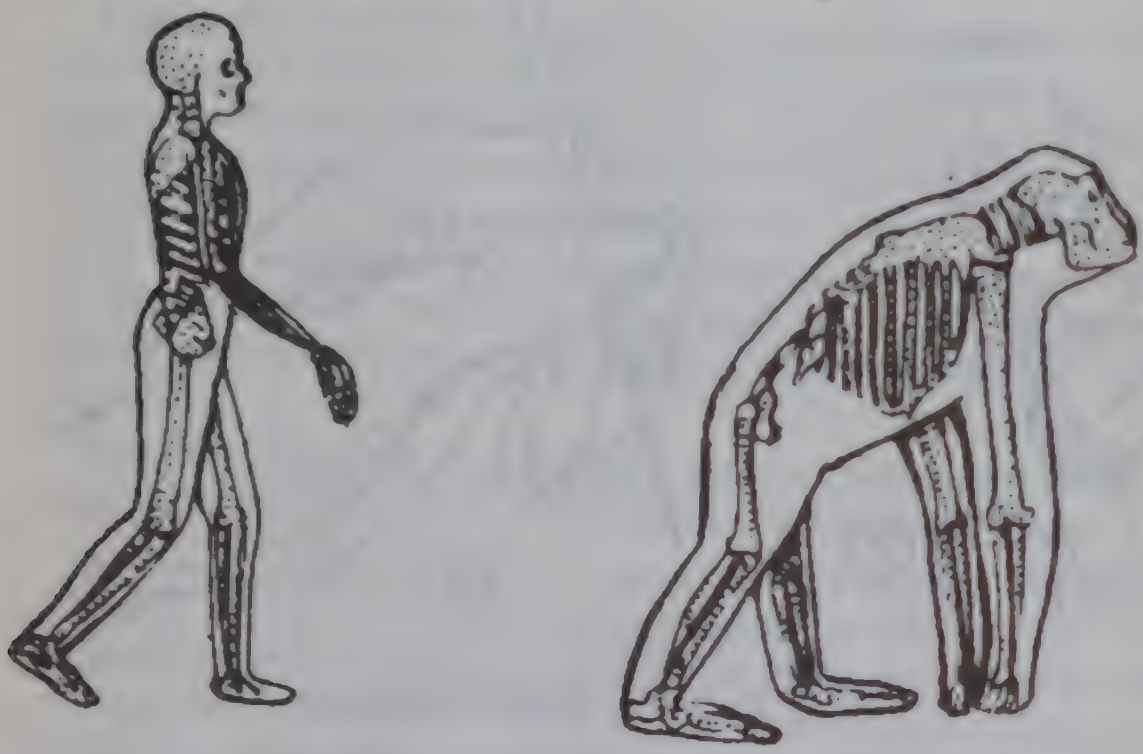

Fig. 7.1 Posture, Limbs and Foot of Man and Ape

2. Legs : The legs(or hindlimbs) of man are very well developed. Their length is more than half that of the body. His thigh bone(femur) is the longest, heaviest and the strongest bone in the body. In other primates and **quadripeds**(animals walking with all the four limbs) the hindlimbs are generally weaker.

3. Pelvis : The pelvis region of man is broader and shorter, allowing a totally erect posture. Certain modifications have occurred in the bones and muscles of the hip and thigh regions associated with the erect posture. In apes the pelvis is larger and longer and as such, cannot allow a totally erect posture.

4. Hands : Since the forelimbs of man are totally free from the task of locomotion, he has the greatest advantage of using the hands for making and using tools. He is able to use his hands for various activities such as picking up an object, for carrying it or even for examining it. The thumb digit is opposable to all other digits. This unique feature has enabled man to develop both **power grip** and **precision grip**. This advantage in man is called **dexterity**. Other primates such as apes and monkeys have only power grip.

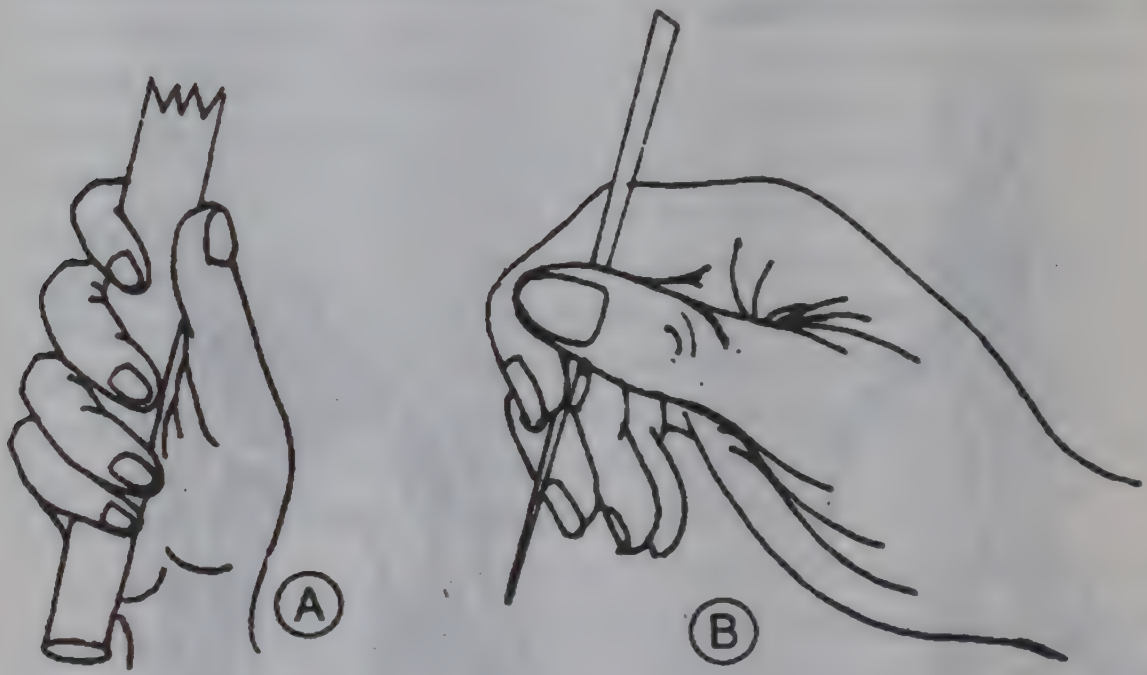

Fig. 7.2. (A) Power Grip; (B) Precision Grip

Activity 7.1 : Observe the role played by the thumb when you are involved in various manual tasks such as writing, threading a needle, handling various objects and so on.

5. Skin : Man's skin is relatively bare compared to the hairy skin of all other primates. Hairs do not uniformly cover the body of a man and occur only in some specific regions.

6. Teeth : The teeth are regular in size and shape. The canine teeth of man are particularly reduced in size when compared to those of other primates.

7. Brain : The relative size of the human brain is much greater than that of apes. The cranial capacity of man is the largest(about 1500 cc). It houses a relatively large brain.

Cerebrum is the largest part of our brain weighing about 1400 g. The surface of the cerebrum, called cerebral cortex, is particularly well developed. It is this development which gives man the capacity for abstract thought. It is said that the intelligence of animals can be fairly accurately studied by looking at the ratio between the weight of the brain and weight of the spinal cord. In cats it is 4:1; in monkeys, it is 8:1; and in man, it is about 55:1.

8. Speech : The power of speech is another unique feature of man. It is only the human species in the entire animal kingdom whlch can converse with its members using spoken words. This unique capacity is one of the final changes in the biological evolution of man. It was the outcome of two important anatomical changes, one in the brain and the other, in the vocal tract. In man the low position of the larynx compared to other mammals, makes the pharyngeal cavity become larger. It enables him to produce a wide range of sounds needed for spoken words.

The development of speech, which led to an exchange of ideas and thoughts, is the most significant feature in the evolution of man.

9. Eyes : The eyes of man, as in other primates, are directed forwards. They are specialized for binocular or stereoscopic vision. Images from the two eyes are together interpreted in the brain to give us a clear three–dimensional view of any object. It provides a vital perception of the object, such as depth, texture, contour and distance.

The human eyes are equipped with colour–sensitive cells called cones. Hence, colour perception is another specialized feature of the human eye. Colour perception helps us enjoy and appreciate the beauty of nature such as sunset, flowers, greenery and so on. Most other mammals are colour blind. Some have the capacity of colour perception, but the mechanism is different from that of humans.

10. Thinking : The capacity to think is another important unique feature of man. It enables him to associate, integrate and make vital decisions. It also helps him to plan ahead. Hence, man is commonly called 'thinking animal'. Thinking and speaking have elevated man above all other mammals.

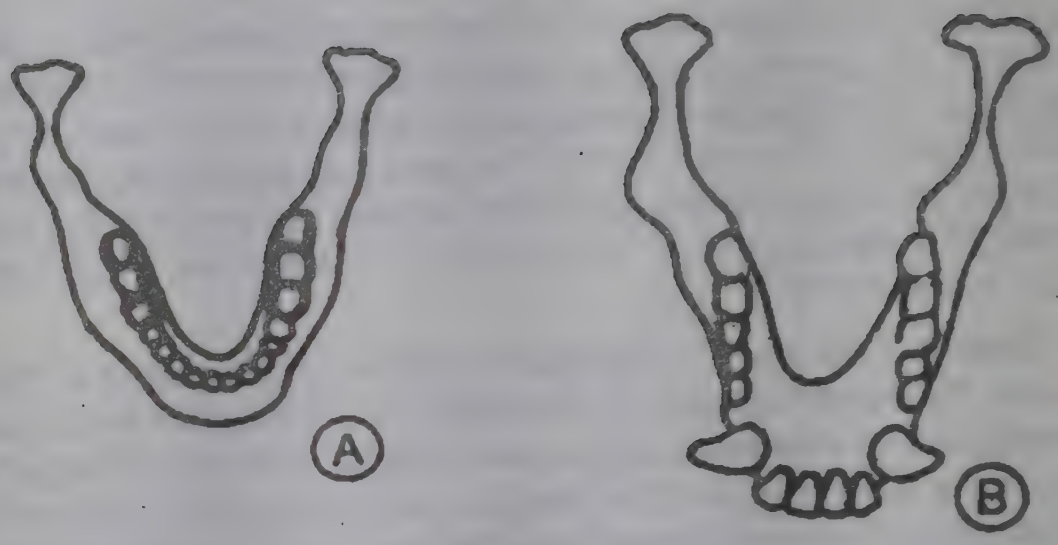

Fig. 7.3. Teeth of (A) Man; (B) Chimpazee

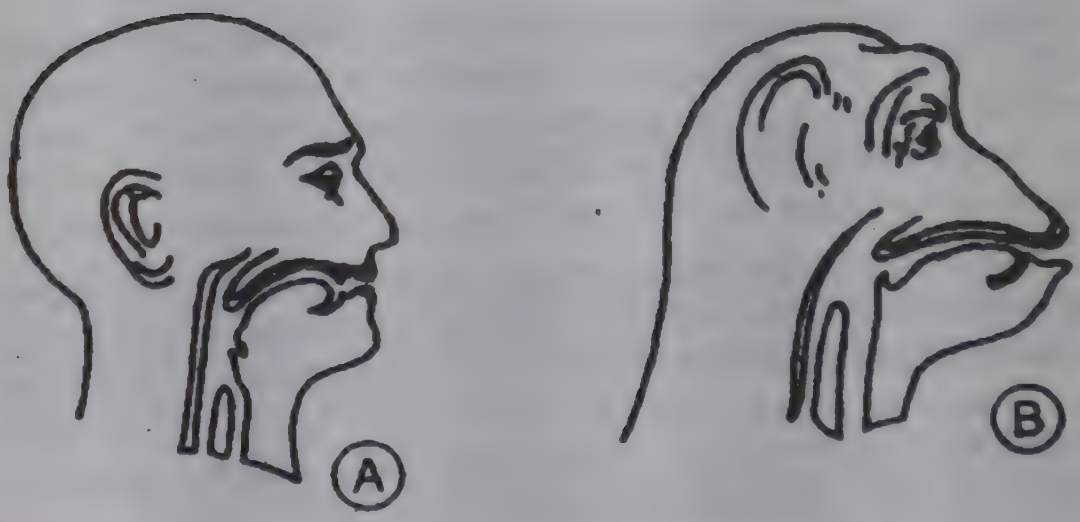

Fig. 7.4. Position of Larynx in (A) in Man; (B) Ape

Activity 7.2 : Mix some red–coloured and green–coloured marbles with those of other colours. Ask your friends to pick up only red–coloured marbles or only green–coloured ones. Some of them will not be able to do so. Why is it so? Try to find out the reason for this condition, called colour blindness.

11. Breeding : A special feature of human reproduction is that he has no special breeding season. All other mammals have specific breeding seasons during which they make. But human beings are capable of reproduction all through the year.

12. Extended Period of Growth : The human beings are the only animals in whom the period between birth and maturity is very long. It is usually divided into four stages:

1. Infantile : from birth to about 10 months;

2. Childhood : from 10 months to about 5 years;

3. Juvenile : from 5 years to about 14 years(till puberty);

4. Adolescent: from 14 years to about 22 years.

Table 7.1

Example	Longevity (in years)
Lion and Tiger	25
Horse	30
Hippopotamus	40
Chimpanzee	40
Indian Elephant	60
Whale	60

13. Longevity : Man is one of the longest–lived animals in the world. He even surpasses the elephants in this regard. Tortoises are perhaps his only competitors in this aspect, although it is not clearly known as to how long these marine animals live.

Thus, the human body shows some unique features which set apart man from other primates and lower mammals. However, all these unique features are the result of millions of years of ceasless process of organic evolution. In fact, every part of the human body bears an imprint of long and complicated vertebrate history, of which he is only a recent participant. This idea is very well expressed by the famous biologist Alfred Romer. For the history of human culture or science or art we have established great museums. But for the history of our most precious possession, our own bodies, they are themselves museums, living witnesses to their own historic past.'

7.3. Structural Limitations of Human Body

When we study the unique features of the human body, it may appear to us that most of these features are to the best advantage of man. However, in reality man lacks many capabilities that are seen in lower mammals. Let us now look into some structural limitations in the human body imposed by evolutionary changes.

* **Limitations of Erect Posture** : We have seen earlier that the totally upright posture of man has provided him several advantages. Most important of them is that the forelimbs are freed from locomotion. However, the bipedal, erect posture has certain disadvantages too. It leads to instability compared to other animals, mainly because the vertical line passing through the centre of gravity of man falls within a narrow range.

Activity 7.3.: Take two dolls, one with a bipedal posture (a baby doll) and the other with a quadriped posture (say, a dog). Observe which one falls down just for a slight push.

Take the example of a calf or a lamb. It is able to stand up within hours of its birth, whereas a human baby needs atleast a year to stand upright. This is because a calf or a lamb has a large base area in which the line of action of its centre of gravity falls.

When we are climbing up a hill, we lean forward. If the normal upright posture is maintained while climbing, the line passing through the centre of gravity falls outside the narrow zone of our feet and as such we may fall. We have to lean forward to bring this line fall within the narrow zone of our feet. The same is the case when we lean backwards while coming down a hill.

Activity 7.4 : Sit on a chair with your back resting against the back of the chair. Try if you can get up from the chair without leaning forward.

In four–legged animals, the skeleton is built on the principle of cantilever bridge, with an arched backbone that rests on all the four limbs. In man, because of the erect posture, the backbone has a

more or less S–shaped curve, resulting in mechanical imbalance. It puts terrible strain on his back and abdomen.

Another clear disadvantage of erect posture is that the entire bodyweight is supported by only the hip girdle. In quadripeds, it is equally supported by both shoulder girdle and hip girdle. As a result, bipedal erect posture often leads to problems associated with backbone and pelvis.

In addition to all these, due to the upright posture, the viscera hang downwards in the abdominal cavity, putting an undue strain on the abdominal muscles. Gravity exerts strong force on these muscles. Thus, the lower abdominal region of man is most vulnerable to injury and ailments.

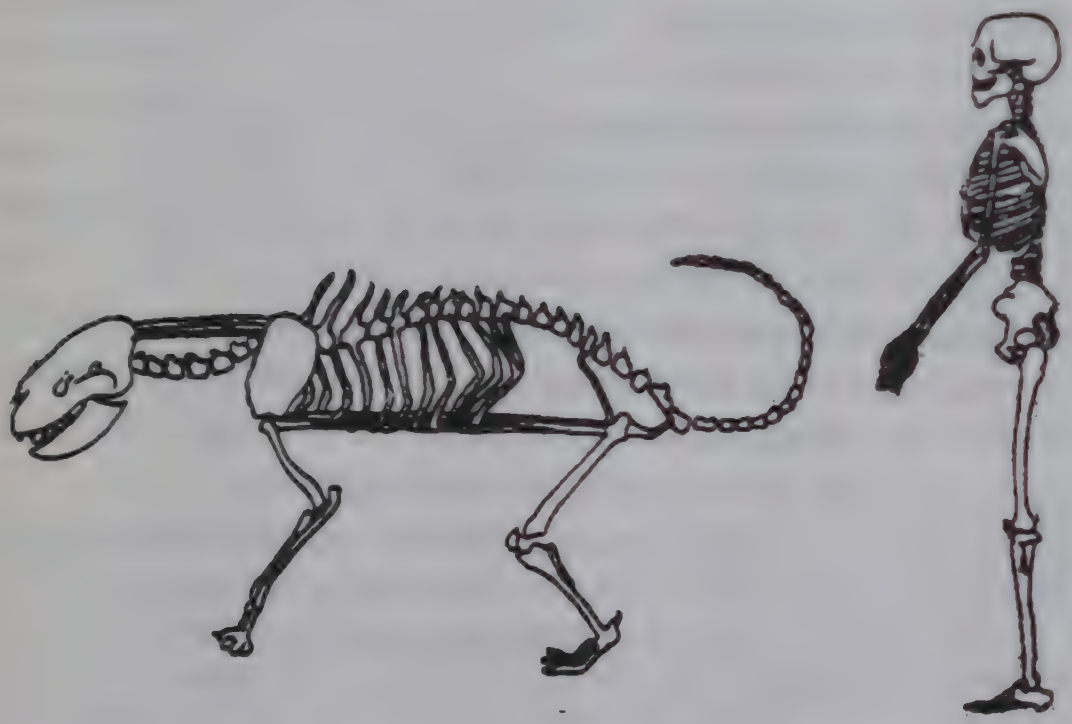

Fig. 7.5. Backbone of Quadriped and Man

The heart of man is located in the thoracic region. In a standing man it is about four feet above the ground level. In such a situation it must pump blood against the force of gravity, particularly to the regions of the head and arms. Such difficulties in circulation may cause 'cold feet' or frost–bitten ears and fingertips.

* **Limitations caused by Loss of Tail :** When you observe a monkey resting on a tree you will notice that it coils its tail around the branch. Sometimes it may even swing from one branch to another with the help of its prehensile tail. Tail becomes an important balancing organ in arboreal animals. The absence of tail in man has restricted him to be a ground–dwelling primate.

* **Limitations caused by Loss of Hair** : The presence of thick hair in the skin of many mammals serves as a natural insulation to maintain the body temperature. It is also a protection against cold. The insulating ability of the hair and the cooling ability of sweat glands combine to give mammals an efficient method of maintaining body temperature. Evolution has deprived man of uniform hair on the body. Loss of hair has led to a rapid loss of heat from the body.

* **Limitations in the Eyes** : We cannot see things in darkness since our eyes can perceive only the wavelengths of visible light. Several mammals like cat and dog can see even in dim light. Their eyes have more number of light–sensitive cells. The pupil of the eye in these animals can expand to a great extent to allow even a very small amount of light.

* **Limitations in the Sense of Smell and Hearing** : The olfactory sense in man is generally rudimentary, while in several other mammals, it helps them to detect their food or mate or enemies. Man has to depend upon his limited vision for such activities.

Most mammals have large, movable pinnae. In man the pinnae are small and immovable. The human ear can perceive sounds of a limited range of wavelength. Only the vibrations ranging between 20 and 20,000 hertz(cycles/sec.) can be registered by our ears. Ultrasonic vibrations(below 20 hertz) are silent as far as human ears are concerned. Mammals like bats, whales and even dogs are capable of registering ultrasonic sounds.

* **Limitations Regarding Nutrition** : Man cannot utilize raw animal food or cellulose fibres, Carnivorous mammals like tigers, lions or dogs

Activity 7.5 : Find out why human beings deploy dogs for various jobs like hunting tracing of criminals and so on.

can tear the flesh and digest the raw animal food. This is because canine teeth are prominent in them.

Cattle, like cows and buffaloes, can eat and digest cellulose fibres present in grass and hay. In these animals, the alimentary canal has fermentation chambers which contain micro organisms that break down cellulose. The intestine is longer in these animals and hence the increased capacity for digestion and absorption. In man such chambers are absent in the alimentary canal and the volume of the intestine is also limited.

* **Limitation Caused by Loss of Defensive Structures** : Many mammals like cats, dogs, bear, tigers, etc. have claws at the end of their digits. Cows and buffaloes have horns. All such structures help them as organs of offence and defence. In man claws are reduced into nails which are almost ineffective as defensive structures.

* **Limitations Caused by Musculature** : Mammals like cheeta, kangaroo and antelopes which are known for their fast running, have a higher proportion of red muscles in their body. The red muscles which contain a pigment called **myoglobin** (similar to haemoglobin of blood) provide the ability for prolonged excercises. Man has a very low proportion of red muscles compared to such mammals. Hence, his ability for prolonged excercises becomes highly restricted.

In spite of these structural limitations man has been able to dominate the earth as the most powerful animal. Being intelligent, he has been able to overcome many of these limitations by way of his inventions and discoveries. He has made good for the loss of hair by inventing clothing. He has invented artificial sources of light to overcome the limitations of his eyes. He has invented fire to cook food and soften it. He has made good the loss of natural defence by inventing weapons.

Thus, he has developed techniques with the use of his skill and knowledge which have made him become the most dominant creature on the earth.

EXERCISES

I. Answer the following questions :

1. Discuss the advantages and disadvantages of erect posture in man..
2. Explain how the human forelimbs are unique compared to those of any other mammals.
3. How do you consider the human brain as the most advanced among mammals?
4. What are the unique features in human reproduction?
5. Explain the limitations in the human body caused by (i) loss of hair; and (ii) musculature.

II. Distinguish between the following :

1. Pelvis of Man and Gorilla
2. Monocular vision and Binocular vision
3. Sense of hearing in man and dog

III. Fill in the blanks :

1. The first examination of human body is presumed to have taken place in_____
2. The longest and strongest bone in the human body is_____
3. In the man the canine teeth are_____
4. The most significant feature in the evolution of man that has led to exchange of ideas, is the development of_____
5. The red muscles contain a pigment called_____

CHAPTER 8

THE HUMAN NEEDS

8.1 Introduction

We have noted in the previous chapter that it becomes inevitable for man to manipulate his environment to overcome some of his structural limitations. In the days of primitive men the situation was that people faced several difficulties as they could not meet some of their requirements. It is such situations that have led man to device various modern appliances and amenities for his welfare and comfort.

The three basic needs of human beings, for their survival, like those of all other animals, are : food, oxygen and water. In addition, they need shelter and clothing to protect themselves and also to adapt to the changing climatic conditions. Apart from these five basic needs, the modern man requires to satisfy a number of other needs in order to make a comfortable, trouble–free living. He has been able to meet most of these needs with the skill and knowledge he has accumulated over the past thousands of years. Science and technology have helped man in changing his ways of life over these years. In this chapter, let us look into the various needs of human society and the problems associated with such needs.

Activity 8.1 : Make a list of all the appliances which are useful to you from the time you get up in the morning to the time you go to bed, such as :

Appliances that preserve food for a long time; and keep your house cool in summer.

Items that are useful to us for relaxing during leisure, for recreation, entertainment and education.

Appliances used in the kitchen and other places in the house.

A variety of other objects and materials that may be useful to you in various ways.

8.2. Classification of Human Needs

The specific needs of man required for a comfortable living may be classified into five types : 1. Biological needs. 2. Physical needs. 3. Cultural needs. 4. Social needs. 5. Aesthetic needs.

Biological Needs : Food, water, oxygen and perpetuation of race can be grouped as the biological needs of man. As long as the human population growth was in control, man did not face the shortage of food or water. As the needs for these increased, man was forced to develop methods and devices which have enabled him to grow more food and get adequate drinking water. He has developed many new techniques for tilling the soil, sowing the seeds and finally, even for reaping the crop. He has also developed new techniques for storing foodgrains for a long time and to control insects and pests which destroy food crops. He has been able to set up many industries related to agriculture, that are involved in meeting the growing demand for food. Some such examples are the fishing industry, the poultry and the piggery.

Activity 8.2 : Make a list of scientific equipments that are used in agriculture.

The survival of the human race, to a great extent, depends on the reproductive behaviour and the parental care exhibited by man. Parental care, in particular, is highly elaborate in human species, compared to other animals.

Physical Needs : Clothing, housing, health and sanitation can be grouped as the primary physical needs of man.

From time immemorial, plant and animal products have been the main source of clothing for man. Gradually, man invented synthetic fibres like linen, nylon and polyester as the demand for clothing increased. The type of clothing varies from region to region and, to a great extent, depends on the climatic conditions. People living in cold regions require warm clothing made of wool or leather. People living in tropical regions need light and thin clothing such as cotton.

Housing has also undergone a series of changes. From the stage of constructing simple hutments made of grass and other plant materials, man has come very far. Today man has revolutioned the concept of

housing. Some of the materials required for housing such as mud, sand, timber and water are being obtained from nature. Many other materials like brick, cement, iron, plastic and glass are the result of technological advances made by man.

At present man has been able to cure a number of diseases like cholera, plague and smallpox which had affected his population in the past. Improved sanitary conditions and recent advances in the field of medicine have enhanced his average life span.

Activity 8.3 : (i) Visit any textile industry to know how cloth is manufactured on a large scale.

(ii) Find out the low cost materials that are now being used in housing.

Cultural Needs : Education, entertainment, arts and sports are some of the cultural needs of man.

Man needs culture in order to lead an orderly life in the society. Education contributes to a great extent to the development of culture. The development of language in the course of evolution has done a great deal in the transmission of gained knowledge from one generation to another.

Entertainment plays an important role in freshening of our minds in these days of mechanical life. Radio, tape recorders and television play an important role in providing entertainment as well as education.

Involving ourselves in arts, crafts and sports is another important aspect of developing culture.

Social Needs : Transport, communication, government, citizenship and freedom are some of the social needs of man.

Man, being basically a social animal, was able to develop villages, towns and cities. He has established a government to take care of his social needs. He has framed a set of laws to govern the society. He has invented various means of transport and communication which have solved many of his immediate problems.

Religious and Aesthetic Needs : Historical and archaeological monuments, temples, mosques and churches, museums, etc., are some of the items which satisfy the aesthetic needs of man.

Once in a way, a visit to a national park or a wild life sanctuary helps us in appreciating the beauty of nature and in developing love towards wild creatures.

Table 8.1. Human Needs and Their Sources

	Type of Needs	Examples	Sources
1.	Biological Needs	Food	Agriculture and associated industries
		Oxygen	Atmosphere
		Water	Rainfall
		Perpetuation of race	Reproduction and parental care
2.	Physical Needs	Clothing	Plant, animal and synthetic fibres
		Housing	Building materials, factories
		Health and sanitation	Medicines, hospitals.
3.	Cultural Needs	Education	Institutions
		Entertainment	Radio, television, cinema
		Arts and crafts	Club and societies
4.	Social Needs	Freedom, co–operation citizenship, proper administration	Villages, towns and cities: local bodies, municipal corporations, government.
		Transport	Railways, road and airways
		Communication	Telephone, telegraph, fax
5.	Religious and Aesthetic Needs	Temples, mosques and churches, archaeological museums and monuments	Preservation of ancient art and sculpture
		Love for nature	National parks, sanctuaries

8.3 Human Needs and Natural Resources

In order to meet many of his needs, man has been depending either directly or indirectly, on nature. Many of the particular biological and physical needs of man are being met with from natural resources.

Apart from the living components represented by the biosphere, our planet earth has a non–living component called **geosphere.** It

is made up of three components : the **lithosphere** which represents the solid part of the earth(the earth's crust); the **hydrosphere** which represents the water covering the earth; and the **atmosphere** which represents the gaseous component sourrounding the earth. These three components of the geosphere provide many of the materials that are required by man.

The **lithosphere** provides a variety of materials that are useful to man. It is the source of soil in which food and other economic crops are grown. It provides the substrate for plants which are useful to man in many ways. It is the reservoir of drinking water. Many varieties of rocks and stones are obtained from lithosphere.

The **lithosphere** also has a wealth of materials in the form of mineral deposits that are being extracted for the benefit of mankind. Various chemical elements, such as copper, iron, aluminium and sulphur, are available in different forms, from the lithosphere. Lithosphere is also the source of precious items such as gold, silver and diamond, which have always fascinated man.

The **hydrosphere** is the source of a wide variety of materials used by man. Oceans, in particular, have been an endless source for many of his needs. They are important sources of marine food. Apart from fishes, a variety of marine animals like crabs, prawns and oysters have been a source of delicious food for man. An important useful product of seawater is the common salt. It is also a source of several elements such as iodine, phosphorous and boron.

Pearls, corals and several other items of ornamental value are obtained from the sea.

In recent years, man has tapped even the underwater petroleum deposits in the sea to obtain natural gas and petroleum products.

An extremely important contribution of the hydrosphere to man is its role in maintaining the water cycle in nature. Oceans are mainly responsible for the formaiton of clouds and the subsequent rainfall.

Activity 8.4 : Draw a water cycle. Study the role played by oceans in the process.

The **atmosphere** is a source of some gaseous chemical substances that are important to man. The most vital of them is oxygen. Nitrogen which is a major component of atmosphere is made available to man through plants. Carbon–di–oxide, which is absorbed from atmosphere by plants during photosynthesis, is also available to man indirectly.

Table 8.2. Gaseous Composition of Atmosphere

Gas	% Composition
Nitrogen	78.0
Oxygen	21.0
Carbon Dioxide	0.03
Others	0.97

Activity 8.5 : Draw the Carbon cycle and study how carbon is used up and recycled.

Some of the rare gases found in the atmosphere have also been put to use by man. Helium is used for filling balloons. Argon is used in electrical bulbs and flourescent lamps. Neon is used in special types of bulbs and tubes that are used in advertising.

Earth's atmosphere spreads upto about 25 kms of its surface. Beyond this is a layer of ozone. It absorbs the harmful ultraviolet radiation from the sun and thereby protects all living organisms.

8.4. Effects of Increasing Needs

The human needs are increasing at an alarming rate. What is the main reason for this increase? Undoubtedly, it is the increase in human population. The world population was about 0.5 billion around 1600 A.D. Around 2000 A.D. it is expected to reach a staggering figure of about 7 billion! Let us see what the situation is in our country. In terms of land area, we stand in the seventh place in the world, occupying only 2.4% of the total land area of the world. However, in terms of population, we occupy the second place in the world. Ours is the second most populous country in the world. Look at Table 8.3. which gives an indication of the trend of population growth in our country. It shows a tremendous increase, particularly after 1951. At this rate, it is estimated that indian population will be doubled in the next 15 to 20 years.

The present birth rate is two children for every three seconds. A large number of these children are forced to death due to malnutrition, poverty and shortage of food.

Increase in human population has also resulted in several other problems such as shortage of drinking water and housing, besides unemployment.

Man depends on forest products for meeting his requirements of wood and paper. With the increase in human population, the demand for forest products has increased enormously. Hence, deforestation has reached alarming proportions, creating an imbalance in nature.

Table 8.3 : Growth of Population in India

Census Year	Population (in millions)
1901	236.2
1911	251.2
1921	253.2
1931	279.0
1941	318.7
1951	361.4
1961	439.2
1971	546.9
1981	683.8
1991	840.0

We are likely to face many more such problems in future if we cannot maintain a balance between our needs and the sources which provide them.

EXERCISES

I. Answer the following questions:

1. List the major human needs.
2. Write a brief note on the biological needs of man.
3. List and describe the primary physical needs of man.
4. Discuss the importance of oceans in satisfying several human needs.
5. What are the immediate effects of increase in human needs?

II. Distinguish between the following:

1. Cultural needs and Social needs of man
2. Biosphere and Geosphere

III. Fill in the blanks:

1. The three basic needs of man, necessary of survival are_____, _____ and _____.
2. Clothing is an example of a_____need.
3. The source of oxygen as a biological need of man, is_____.
4. The main cause of increase in human needs is_____.

NATIONAL ANTHEM

Janagana mana adhinayaka, jaya he
Bharata bhagya vidhata
Punjaba Sindhu Gujarata Maratha
Dravida utkala Vanga
Vindhya Himachala Yamuna Ganga
Uchchhala Jaladhi Taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha
Jana gana mangala dayaka, jaya he
Bharata bhagya vidhata
Jaya he, jaya he, jaya he,
Jaya jaya jaya, jaya he

ಶಾಲಾ ಮಕ್ಕಳಿಗಾಗಿ ಪಠ್ಯ ಆಧಾರಿತ ಆಕಾಶವಾಣಿ ಕಾರ್ಯಕ್ರಮ

ಪ್ರಸಾರದ ವೇಳೆ : ಪ್ರತಿ ಸೋಮವಾರದಿಂದ ಗುರುವಾರದವರೆಗೆ
ವಾರದಲ್ಲಿ ನಾಲ್ಕು ದಿನಗಳು, ಅಪರಾಹ್ನ 2.30ರಿಂದ 3.00

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(1855-1937)

The momentous discovery that plants, like other living beings, also throb with life was made by the renowned Indian scientist, Sir Jagdish Chandra Bose. The world was greatly surprised to hear about this new and wholly unexpected discovery of Bose. With the help of various scientific instruments, invented by Bose himself, he demonstrated that plants too live, drink, sleep and breathe as all other living beings.

Though Bose's fame rests mainly on his above discovery, yet, he also made another very important discovery-the discovery of wireless telegraphy. True, that around the same time the Italian scientist, Marconi, was also conducting experiments on transmission of radio signals, but for this purpose he used `long electric waves'. While Bose discovered and used `short waves' which later came to be commonly used in `Radar' and `Television' etc. Bose was nominated to represent India at the International Science Congress held in Paris in 1900. There, Bose expounded his scientific theories and the world scientists were astonished at his amazing talent. The London University conferred `Doctor of Science' (D.Sc.) on Bose in 1896. The Calcutta University also conferred D.Sc. on Bose in 1917. The British Government of India honoured Bose by conferring on him the title of `Sir'. In 1920, he was elected a Fellow of the Royal Society of London. Bose founded the Bose Research Institute in Calcutta.

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